

Ecological Risk Assessment of Dicks Creek, Middletown, Ohio

by

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Prepared for:
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November 9, 2000

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U.S. Environmental Protection Agency Region 5
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Subject: Preliminary Draft "Ecological Risk Assessment of Dick's Creek, Middletown, Ohio"
EPA Contract No. 68-W9-9018, Work Assignment No. R05805

Dear Ms. Geist:

Tetra Tech EM Inc. (Tetra Tech) is submitting a preliminary draft copy of the "Ecological Risk Assessment of Dick's Creek, Middletown, Ohio" prepared by Tetra Tech's subcontractor AquaQual Services, Inc. (AquaQual). While Tetra Tech has reviewed and commented on an earlier version of this report, Tetra Tech has not completed its contractually required quality control (QC) review of this report. Tetra Tech is submitting this preliminary draft copy of the report to facilitate the U.S. Environmental Protection Agency's (EPA) timely input to this report, a key deliverable on a highly visible project.

It should be noted that the report is identified as a final report. Tetra Tech considers the report to be a draft and is identifying the report in this context as a preliminary draft because it has not undergone Tetra Tech's required QC review. Also, the cover identifies the authors as associated with Wright State University. While it is true the authors work at the university, the report was prepared by the authors as employees of AquaQual; the author's affiliation will be revised accordingly on the formal deliverable.

Please call me at (312) 856-8797 if you have any questions regarding this preliminary draft report or the work assignment in general.

Sincerely,

Eric Morton
Environmental Scientist

Enclosure

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Executive Summary

Approach Overview

An Ecological Risk Assessment (ERA) was conducted on Dicks Creek, located in Middletown, Ohio. The U.S. Environmental Protection Agency (USEPA) Region V requested Wright State University (WSU) to conduct a screening level ERA using data from WSU and Ohio Environmental Protection Agency (OEPA) studies. The ERA was multi-faceted, consisting of a comprehensive evaluation of conditions in the stream using laboratory and *in situ* assays of toxicity, bioaccumulation of chemicals (indigenous tissues and *in situ* assays), benthic macroinvertebrate and fish community indices, physicochemical characterization of waters and sediments, and modelling of food web uptake and effects. Each approach provided unique information useful in assessments of ecosystem degradation. Risk was evaluated using a quotient method combined in a weight-of-evidence (WOE) approach. Each individual assessment approach determined if effects were significant using comparisons to control/reference values, toxicity reference values, benchmark biological effect values, water and sediment quality guidelines (SQGs), and/or modeled values. Uncertainty in the ERA was evaluated by comparisons of various ERA model assumptions/approaches commonly found in the peer-reviewed literature. The ERA consisted of Problem Formulation, Exposure and Effects Characterization and Risk Characterization stages.

Tetra Tech, who subsequently contacted WSU...

Problem Formulation

The Problem Formulation stage of the ERA assessment focused on receptors that were commonly observed at the site and surrogate species that were exposed in *in situ* and laboratory assays. The primary receptors of concern identified in the study area were:

Trophic Level 1: Macrophytes and Algae

Trophic Level 2: Oligochaetes, Midge, Amphipods, Emergent Insects and Bivalves

Trophic Level 3: Minnow, Carp, Catfish, Crayfish, Swallow, Mallard and Raccoon

Trophic Level 4: Kingfisher and Great Blue Heron

The Assessment Endpoints were:

- 1) Benthic community structure as a food source for local fish and wildlife
- 2) Protection and maintenance (survival, growth, and reproduction) of local fish (forage, omnivorous, and piscivorous)
- 3) Protection and maintenance (survival, growth, and reproduction) of local insectivorous birds
- 4) Protection and maintenance (survival, growth, and reproduction) of local waterfowl

- 5) Protection and maintenance (survival, growth, and reproduction) of local piscivorous birds
- 6) Protection and maintenance (survival, growth, and reproduction) of local wildlife

The Measurement Endpoints were:

- 1) Benthic and fish community metrics;
- 2) *In situ* and laboratory assay toxicity (survival) and bioaccumulation (tissue residues);
- 3) Measured and modeled tissue concentrations of PCBs in receptors vs. exceedence of effect-level thresholds;
- 4) Exceedence of water quality criteria and SQGs; and
- 5) Field measurements and observations.

Chemicals of Potential Concern: Exposure and Effects

Polychlorinated biphenyls (PCBs) were determined to be the chemicals of Potential Concern (COPC). Water, sediment and tissue data collected from the study area from 1996 to August 2000 were reviewed. Low to non-detectable concentrations of volatile compounds were measured. Polycyclic aromatic hydrocarbons (PAHs) were present in the study area and are a common by-product of steel mill operations. Total PAH SQGs were not exceeded; however, some individual PAH SQGs were. Pesticides were detected in Dicks Creek in a 1995 Ohio Environmental Protection Agency survey; however, they were not observed in water and sediment samples from 1999 and 2000. Metals exceeded SQGs; however, in 2000 only Cd and Zn exceeded lower threshold levels (e.g., Effects Range Low). In the previous year, Cd, Cr, Cu, Pb and Zn concentrations in the Landfill Tributary exceeded multiple lower threshold effect levels and Cd, Pb and Zn also exceeded Extreme Effect Levels. Silver was the only metal, exceeding the USEPA water quality criteria. However, hardness in Dicks Creek is typically above 300 mg/L CaCO₃, so metal criteria will rarely be exceeded. There is likely only a limited impact to benthic macroinvertebrates from metals. Recently, total PCB concentrations in reference site sediments (Todhunter Road and upstream of the confluence of the North Branch Dicks Creek) ranged from non-detectable to 2.82 µg/Kg and downstream test site sediments (USGS to Amanda; RM 2.45 to 1.63) ranged from 10 to 628.8 µg/Kg, depending on the exposure and test treatment. PCB concentrations at the Landfill tributary (RM 2.71) downstream to the lowest test site at Amanda (RM 1.63) consistently exceeded water and SQGs and were elevated in tissues of resident fish and benthic macroinvertebrates. Total PCB sediment concentrations at Amanda and USGS (2000) ranged from 130 to 200 µg/Kg,

exceeding lower threshold effect levels. Aroclor concentrations in 1999 exceeded Extreme Effect Levels.

Indigenous Biota Surveys

In the OEPA 1995 biological water quality study of the Great Miami River and its tributaries (OEPA, 1997), non-attainment status was reported at all of the sampling locations surveyed in Dicks Creek due to poor and very poor macroinvertebrate and fish criterion. Macroinvertebrate communities throughout Dicks Creek were severely impacted and exhibited low diversity with only pollution tolerant species occurring. ICI scores ranged from 6 to 12. The fish communities ranged from very poor to good prior to an AK spill in 1995. Following the spill, a massive fish kill occurred and most species were lost. *spell out of what?*

A qualitative survey of the benthic macroinvertebrates was conducted twice during the summer of 2000. During the June sampling period, no benthic invertebrates were recovered at the USGS site with sediment core sampling. Only small numbers of leeches and caddisflies were recovered with surficial sediment sampling. At the Amanda site, core sampling recovered one leech and numerous dead *Corbicula fluminea* (Asian clam). Surficial sediments in a nearby riffle had many chironomids and caddisflies, and small numbers of riffle beetles, mayflies, isopods, and *C. fluminea*. In the August, 2000 sampling no organisms were recovered with the core sampler. Surficial sediments at the USGS site were devoid of macroinvertebrates. However, at Amanda, there was a large population of midges (chironomids) and one to a few *C. fluminea*, caddisflies, mayflies and beetles. Again, many dead adult *Corbicula* were noted. Surficial sediments at Todhunter Road (a nearby reference) recovered many flatworms, and one to a few isopods, amphipods, crayfish, mayflies and caddisflies. Both the WSU and OEPA macroinvertebrate sampling results were similar showing poor quality, with very low densities, pollution tolerant organisms, and evidence of high clam mortality. *showed results incl. habitat of what?* Habitat quality at the USGS and Amanda sites was reasonably good, therefore was not considered a stressor.

In Situ Assays

NS *were conducted*
In situ assays using caged organisms that separated exposures to water column, sediment/water interface, surficial sediment and water, and pore water from deeper sediments. In the laboratory, short-term assessments of organism mortality and growth were also conducted using *Daphnia magna*, *Pimephales promelas*, *Hyalella azteca* and *Chironomus*

tentans. In addition, bioaccumulation was assessed *in situ* using *Lumbriculus variegatus*, *H. azteca* and *C. tentans* and in the laboratory using *L. variegatus* for 2 d to 4 wks.

The test sites for *in situ* assays in 1998 through 2000 were at reference sites (Elk Creek, Caesar Creek or Little Sugar Creek, and at downstream test sites called USGS (RM 2.45), Beaver Dam (RM 2.36) and/or Amanda (RM 1.63). Each of the 3 lower sites (RM 2.45 to 1.63) were below all AK Steel outfalls and were acutely toxic, containing elevated levels of PCBs. For *in situ* exposures, organism response (e.g., mortality) and tissue concentrations there were *showed* some significant correlations with PCB contamination of sediments. *In situ* sediment exposures significantly reduced survival at sites with PCB contamination (low mg/Kg concentrations). Adverse effects were observed *in situ* with sediment PCB concentrations as low as 133 µg/Kg PCB. In general, the highest mortality was associated with organism exposures *in situ* to surficial sediments and/or pore waters where PCB concentrations were higher. *In situ* survival was better related with PCB concentrations measured inside the exposure chambers, than with concentrations outside the chambers. This highlights the importance of accurately measuring organism exposures.

Laboratory Assays

Survival in laboratory whole sediment assays tended to be *greater* *less* than *in situ* exposures to pore water or containing sediments, but worse than water column or against sediment exposures for *H. azteca* and *C. tentans*. This may be that exposure to sediments was reduced in these 2 later *in situ* treatments. No effect was observed in laboratory assays in 2000, showing the *in situ* exposures are more sensitive, as observed in other studies. In addition, PCB concentration trends observed from laboratory sediments did not match *in situ* results suggesting that *in situ* studies are more accurate.

The presence of PCBs was significantly correlated with tissue concentrations and organism survival in multi-year evaluations. PCB isomer patterns in tissues of exposed organisms (*L. variegatus* and *H. azteca*) were similar to those found in sediments at the same sites. Total PCBs in *L. variegatus* tissues exposed for 4 days in the laboratory were ~ 1000 µg/kg while *in situ* concentrations were up to ~356 µg/kg in surficial sediment exposures. Concentrations in sediments, waters and tissues in June and August 2000 were lower than in previous years, yet still exceeded water and SQGs and biological effect thresholds.

Food Web Modelling

Using the trophic levels and receptors identified in the Problem Formulation stage, a food web conceptual model was developed and evaluated. Key receptors in the food web model for which adequate data existed and which were commonly observed in Dicks Creek were modelled. Tissue concentrations and daily doses of total PCBs were estimated using a variety of approaches that have different assumptions, to better evaluate the validity of the predictions. A concern was the potential for magnification of errors as COPC levels are estimated at higher trophic levels. Therefore, measured concentrations of total PCBs in the sediments and tissues of invertebrates and fish sampled from Dicks Creek were used in calculations wherever possible. In addition, tissue residue data, if available for a receptor, were compared to the results of the model predictions to validate the approach. This use of empirical data was critical to the reduction of uncertainty at the bottom of the food chain. Below is a summary of the Exposure and Effects Modelling results:

- 1) The exposure analysis for benthic infaunal invertebrates, represented by *Lumbriculus variegatus*, resulted in accurate estimates of total PCBs. A bioaccumulation model that incorporated ingestion and chemical and food assimilation efficiencies provided the closest estimate to actual tissue concentrations observed.
- 2) All models provided adequate predictions of actual tissue concentrations of field-exposed chironomids. However, the BSAF (biota/sediment accumulation factor) approach provided the closest agreement between predicted and measured tissue PCBs.
- 3) The "Ingestion" and the "BAF" (biota accumulation factor) models resulted in expected tissue concentrations in mayflies that were similar to values reported in the literature. Both models provided close agreement between predicted and measured concentrations of PCBs bioaccumulated by mayflies.
- 4) All model predictions of PCB concentrations using BCF (bioconcentration factors), BAF and BSAF for omnivorous fish were in close agreement with body burdens in fish from Dicks Creek.
- 5) The estimated daily dietary doses and tissue concentrations of PCBs in belted kingfishers from exposure and accumulation models were in close agreement with literature values for other piscivorous species.

Risk Characterization

The analyses of exposure and effects provided the foundation for the risk characterization. This weight of evidence approach integrated the results of the various assessment methods. Using both *in situ* and laboratory assays provided useful information on the source compartment (*i.e.*, sediments) and acute to chronic effect thresholds and exposures (tissue residues), thereby contributing to the weight-of-evidence assessment process. Risk was also characterized by comparing site chemistry to water and sediment criteria/guidelines, and to literature-based toxicity endpoints and toxicity reference values (TRVs). This was primarily done through the use of hazard quotients (HQs) and sediment toxicity quotients (STQs). Information from the latter were used in quotient method comparisons to describe the risk to receptors. Summary conclusions from the measurement endpoints generated by each assessment approach include:

- 1) PCB concentrations consistently exceeded water and SQGs and were elevated in tissues of resident fish and benthic macroinvertebrates. Total PCB sediment concentrations at Amanda and USGS currently range from 0.13 to 0.2 mg/Kg, exceeding lower threshold effect levels. Aroclor concentrations at the Landfill Tributary and also downstream in 1999 exceeded Extreme Effect Levels. The SQGs used for evaluating the significance of PCB contamination in this study are widely used throughout North America. These criteria have been found to be very reliable as predictors of adverse biological effects. While metals are elevated, the extremely high hardness occurring in Dicks Creek renders them biologically unavailable. The exceedance of PCB SQG values suggests adverse conditions exist in Dicks Creek due to PCBs. Total PAHs did not exceed SQGs, however, some individual PAHs were elevated and may pose a threat to organisms in the presence of sunlight due to photo-induced toxicity.
- 2) Benthic macroinvertebrate communities are of poor quality, with few species present, pollution tolerant species dominating, and evidence of high clam mortality.
- 3) Fish communities have been of poor quality in recent surveys. The habitat of Dicks Creek in the study area downstream of the Landfill Tributary is reasonably good. There is a good riparian zone with adequate habitat allowing for a high diversity of birds and small mammals to exist. Despite the reasonable habitat, the benthic and fish community surveys are of poor quality. This is likely due to adverse ecological effects of PCBs.
- 4) High mortality was observed in organisms exposed to sediments during *in situ* assays.
- 5) Tissue concentrations of PCBs quickly became elevated in organisms exposed to sediments. Benthic macroinvertebrates become contaminated with PCBs and act as vectors

of contamination to higher trophic position predators such as fish, amphibians, mammals and birds.

- 6) PCB tissue concentrations showed significant correlations with PCB concentrations in sediments.
- 7) The majority of the HQ calculations used to characterize risks to omnivorous, sediment-associated fish species predict severe impacts from PCBs in Dicks Creek.
- 8) Belted kingfishers in Dicks Creek are at high risk for deleterious reproductive and acute effects, including death. This conclusion even applies to birds that may feed as little as 10% of the time in Dicks Creek. The modeled predictions suggest harm will occur to organisms in higher trophic levels that feed on lower trophic level benthic invertebrates. These receptors of concern occur at Dicks Creek.

This weight of evidence firmly establishes causality, linking extreme adverse effects in biota associated with Dicks Creek to PCB contamination. Based on these findings, the summary conclusions on risk to the Assessment Endpoints are as follows:

- 1) Based on all assessment approaches, there is a high risk of PCBs adversely impacting the benthic community structure as a food source for local fish and wildlife;
- 2) Based on the food web link of the benthic macroinvertebrate community and fish, and PCB tissue contamination of both, there is a high risk of PCBs adversely impacting the survival, growth, and reproduction of local fish (forage, omnivorous, and piscivorous);
- 3) Based on the presence of benthic insects which emerge and their PCB contamination, there is a risk of PCBs adversely impacting the survival, growth, and reproduction of local insectivorous birds, such as the swallows.
- 4) Based on the PCB contamination of sediments and benthos, there is a risk of PCBs adversely impacting the survival, growth, and reproduction of local waterfowl.
- 5) Based on the modelling predictions and PCB contamination of fish, there is a high risk of PCBs adversely impacting the survival, growth, and reproduction of local piscivorous birds.
- 6) Based on the PCB contamination of sediments, benthos and fish, there is a risk of PCBs adversely impacting the survival, growth, and reproduction of local wildlife that feed on biota in Dicks Creek.
- 7) Given the channelized nature of Dicks Creek and the high flows that exist, there is a high likelihood for transport of contaminated surficial sediments downstream.

Introduction

An Ecological Risk Assessment (ERA) was conducted on Dicks Creek, located in Middletown, Ohio. The ERA was multi-faceted, consisting of a comprehensive evaluation of conditions in the stream using laboratory and *in situ* assays of toxicity, bioaccumulation of chemicals (indigenous tissues and *in situ* assays), benthic macroinvertebrate and fish community indices, habitat quality, physicochemical characterization of waters and sediments, and modelling of food web uptake and effects. Each approach provided unique information useful in assessments of ecosystem degradation. Risk was evaluated using a quotient method combined with a weight-of-evidence (WOE) approach. Each individual assessment approach determined if effects were significant using comparisons to control/reference values, threshold residue values, benchmark biological effect values, water and sediment quality guidelines, and/or modeled values. Uncertainty in the ERA was evaluated by comparisons of various ERA model assumptions/approaches commonly found in the peer-reviewed literature. The following sections will describe the Problem Formulation, Exposure and Effects Characterization, and Risk Characterization phases of the ERA using the WOE approach.

Problem Formulation

Site Description

The City of Middletown has a population of 55,000 and is located approximately 30 miles south of downtown Dayton and approximately 45 miles north of downtown Cincinnati (Figure 1). AK Steel, the city's largest employer, produces flat rolled steel and intermediate products of pig iron and coke in addition to steel finishing and coating.

The main branch of Dicks Creek, a tributary of the lower Great Miami River basin, is a 10.5 mile first order stream draining 47.6 mi² in Warren and Butler counties. The headwaters are located in southeastern Warren county near Manchester Road.

Study sites on Dicks ^{Creek} were chosen on the basis of either historic sediment contamination levels or proximity to known point source areas of concern (e.g., AK Steel outfalls) (Figure 2). Between 1996 and 2000, a total of seven test sites (five on Dicks Creek and two reference sites) have been evaluated by researchers at Wright State University's Institute for Environmental Quality for potential toxicity via both laboratory (USEPA and non-USEPA test methods) and field (*in situ*) studies. *In situ* toxicity testing has been focused in and around the

main AK Steel facility located on the main branch of Dicks Creek running east/west, parallel to Oxford State.

The Landfill tributary site (~Rm 2.55) is located in the mouth region of an unnamed tributary (a.k.a. Monroe drainage ditch) that flows south to north, entering the main branch of Dicks Creek just north (upstream) of Yankee Road. This tributary flows through agricultural and industrial areas as well as several closed landfills. Landfill(s) adjacent to this tributary, contain improperly stored polychlorinated biphenyls (PCBs) that are believed to have ultimately leached from seeps in the landfill into the surrounding soils and sediments of the tributary. PCBs emanating from these seeps are believed to be the principal source of contamination to this system. PCBs that have leached from the landfill adhere to the fine particulate sediments and slowly wash into the system, acting as a constant source of contamination. The highest concentrations of PCBs measured in Dicks Creek were from sediments and organisms collected from the landfill tributary area. *site?*

Control studies were conducted for all toxicity testing at carefully selected field reference sites. Near Dicks Creek is Elk Creek, a tributary of the Lower Great Miami River (Rm 49.80), located just northwest of Middletown in the adjacent rural area of Madison Township (~Rm 3.7) (Figure 3). Elk Creek was chosen as it is in the same watershed yet outside of the influence of AK Steel. Elk Creek is also considered a clean reference site by OEPA. Little Sugar Creek, a comparable size stream located in Bellbrook, Ohio was also used (Figure 4).

Organisms observed living in or near Dicks Creek have included invertebrates, fish, reptiles, amphibians, birds, mammals and several plant species. All of these organisms may be directly exposed to PCBs from contaminated sediments, river water, and air, and/or indirectly exposed through ingestion of food and sediments containing PCBs. Adults and children have been observed swimming, fishing and playing in and around all tests sites on Dicks Creek on many occasions. Humans have thus been directly exposed to water, sediment and contaminated fish (filleted fish carcasses have been observed on the banks of the creek).

The Ohio Water Quality Standards (WQS; Ohio Administrative Code 3745-1) consists of designated uses which includes biological criteria designed to represent measurable properties of the environment consistent with goals specified by aquatic and non-aquatic life use designations. In Ohio, aquatic life use designations drive the stringent protection and

restoration requirements for Ohio's rivers and streams. Of the five aquatic life use designations defined in the Ohio WQS, Dicks Creek falls under the category of a Modified Warmwater Habitat (MWH). A MWH generally results from extensively maintained, often permanent hydromodifications not amenable to Warmwater Habitat (WWH) assemblages (OEPA, 1997).

Chemicals of Potential Concern

The OEPA conducted a biological and water quality survey of the middle and lower Great Miami River and selected tributaries as part of its yearly evaluation of the streams and rivers of Ohio. Results of this survey were published in the OEPA document: Biological and Water Quality Study of the Middle and Lower Great Miami River and Selected tributaries, 1995 (Montgomery, Warren, Butler and Hamilton Counties, Ohio) (OEPA 1997). Although the information in this document dates back to 1995, it contains, if not the most recent, the most comprehensive database of biological and water/sediment quality data available. Data from this document was used to delineate historical contamination and its spatial distribution.

The 1995 OEPA biological and water quality study noted that a total of 136 NPDES violations and 58 unauthorized discharges from AK Steel to Dicks Creek were reported to the OEPA between 1990 and 1995. Ninety-four percent of these violations were exceedences for zinc, phenol, total suspended solids (TSS), free cyanide, flow, ammonia-N and nickel. Wastewater was the most common material spilled, of which, the majority of spills were flushing liquor. Other reported spilled materials included: oil, sulfuric acid, benzene, pickle liquor coal tar, coke oven waste, fuel and PCBs (one occasion totaling seven gallons) (OEPA, 1997).

Surface water samples collected by OEPA in Dicks Creek exceeded Ohio water quality criteria (Ohio Administrative Code 3745-1) for pesticides including: aldrin (0.006 µg/L), dieldrin (0.004 – 0.015 µg/L), endrin (0.005 – 0.01 µg/L) and endosulfan II (0.004 µg/L). Also exceeding Ohio water quality criteria were: selenium (33 µg/L), lead (16 µg/L) and zinc (206 – 564 µg/L), aniline, dibenzofuran 2-methylphenol 3,4-methylphenol, phenol and total PAHs (615.7 µg/L). Surface water samples collected in 1999 by OEPA and in 2000 by Wright State University yielded no exceedences of Ohio water quality standards for PAHs, metals, volatile organic compounds (VOCs) or semi-volatile organic compounds (SVOCs). PCB levels, however, exceeded Ohio Water Quality criteria (0.79 ng/L) by several orders of magnitude from surface waters collected by OEPA in 1999 (873 – 3065 ng/L) and Wright State University in 2000 (19 – 70 ng/L). PCBs are generally associated with organic particulate matter (*i.e.*, suspended solids) and sediments

due to the lipophilic/hydrophobic nature of PCBs. During the 1995 survey, OEPA reported slightly to moderately elevated levels of total suspended solids.

USEPA guidelines developed to protect human health for exposures via drinking water for PCB 1016, recommend levels ≤ 0.0035 mg/L for adults and ≤ 0.001 mg/L for children (ASTDR). OEPA guidelines for PCBs in ambient water (e.g., lakes, rivers and streams) is 0.79 ng/L, which reflects a risk of one person developing cancer in populations of 10,000,000 to 100,000 people (ASTDR). Acute and chronic values established for freshwater ambient water quality criteria are 2 and 0.014 mg/L respectively (USEPA, 1986). PCB levels in the surface water at Dicks Creek exceed these levels by one to several orders of magnitude. The Food and Drug Administration (FDA) recommends PCB limits of 0.2 to 3 ppm (milligrams PCBs per kilogram of food) in infant foods, eggs, milk and poultry.

Smith et al. (1996) developed freshwater sediment quality assessment values based upon benthic community compositions and freshwater toxicity test results to calculate a threshold effects level (TEL) and a probable effects level (PEL) for metals and organics. The TEL estimates the concentration of a chemical below which adverse biological effects only rarely occur and the PEL estimates the concentration above which adverse effects frequently occur. Similar total PCB, metal and pesticide effect levels for freshwater and estuarine ecosystems were developed by MacDonald et al. (2000a,b) in a consensus sediment effects concentration approach in which threshold effect concentrations (TECs), midrange effect concentrations (MECs) and an extreme effect concentrations (EECs) were estimated. The TEC estimates the range below which adverse effects are unlikely to occur, the MEC (estimates a range above which adverse effects frequently occur, and the estimates the range above which adverse effects usually or always occur (Table 1). Swartz (1999) developed similar consensus based SQGs for total and individual PAHs (Table 2).

Sediments collected in 1995, 1997, 1998 by OEPA and in 2000 by Wright State University for PAH analysis were below consensus based SQGs for total PAHs (Table 2). However, between 1995 and 1999, a few individual PAHs detected in samples collected from the mouth of the landfill tributary did exceed SQGs. In 1999 fluorene (8.5 mg/kg) exceeded the TEL and the Effects Range Low (ERL), in 1997, benzo(a)anthracene (11.2 mg/kg), benzo(b)fluoranthene (8.4 mg/kg) and fluoranthene (4.3 – 67.8 mg/kg) exceed the TEL, and in 1995 levels of fluorene (552 mg/kg) and phenanthrene (87.2 mg/kg) exceed all sediment SQGs (Tables 3,4). Sediment

concentrations of VOCs and SVOCs from the samples collected at that same sites fell below minimum criteria for aquatic life.

In May of 1997 and September of 1995, OEPA reported organochlorine pesticides in sediment samples collected from AK Steel outfalls 003 and 002 (4,4'-DDE, Dieldrin, Methoxychlor, Mirex and gamma-chlordane). Dieldrin, the only pesticide from that group for which there are SQGs, exceeded the Minimal Effect Threshold (MET). Sediments collected by OEPA in 1998, 1999 and in June of 2000 by Wright State contained no measurable pesticides.

Sediment samples collected at several locations in Dicks Creek by OEPA in 1995 contained elevated levels of zinc (1360 mg/kg – RM 3.00), nickel (232 mg/kg – RM 5.21), chromium (66.8 mg/kg – RM 5.21), arsenic (13.9-17.7 mg/kg RM 5.21), copper (34.6-37.7 mg/kg – RM 4.7), cadmium (1.5 mg/kg - RM 0.93) and manganese (500 mg/kg – RM 0.93). According to OEPA guidelines, zinc, nickel and chromium were “extremely elevated”, cadmium was “highly elevated” and arsenic, copper, aluminum and manganese were “elevated” (OEPA, 1997). However, these guidelines are simply based on statewide percentiles and not related to biological effects and the other SQGs are. In 1997, silver levels in water column samples collected by OEPA from the mouth of the Landfill tributary (40 µg/kg) exceeded USEPA acute water quality criteria (Table 5). Sediments collected from the USGS site in June of 2000, exceeded the ERL (Tables 6,7) for cadmium and zinc. Cadmium exceeded the TEL, the Lowest Effect Level (LEL) and the Minimal Effect Threshold (MET). Zinc exceeded all of the above in addition to the ERL and the Consensus Based Threshold Effect Concentration (CB TEC) (MacDonald 2000a).

In 1996 and 1997, total PCBs were detected at the Landfill tributary sediments (RM 2.55) at 1281 µg/kg and 33,210 µg/kg, respectively. Sediments collected down stream of the landfill tributary (RM 2.6) in 1998 contained 2637.3 µg/kg total PCBs. In June and August of 2000, sediments collected between USGS and Amanda, contained total PCB concentrations between 135.2 to 198.1 µg/kg all of which exceed Threshold Effect Concentrations (Table 8). The TEL and the PEL for total PCBs in sediments is 34.1 µg/kg and 277 µg/kg, respectively (Smith, 1996). Sediment collected by OEPA in 1998 and 1999 from the mouth and downstream of the landfill tributary (500 – 2,800 yards) yielded Aroclor levels (1242 and 1242) that exceed SQGs by several orders of magnitude (Tables 9,10).

Note that the above discussion on water and sediment concentrations of PCBs and their exceedance of SQGs applies to the Exposure Characterization and Effects Characterization aspects, respectively, of the ERA process.

Summary of Chemicals of Potential Concern

Although, metals, PAHs, PCBs and pesticides have been detected in either water or sediment samples collected from various locations in Dicks Creek, PCBs are considered to be the chemical of Potential Concern (COPC) due to their high concentrations, persistence, and ability to accumulate in animals and humans. Metals, pesticides and PAHs detected in Dicks Creek have been found to vary temporally and spatially from year to year, whereas PCBs have consistently been detected above SQGs at the same sites year to year in both sediments and water. Although PAHs, metals and pesticides do not appear to be the primary contaminants, they may be contributing to stress and/or interacting in an additive or synergistic fashion. The above discussion is summarized as follows:

- Metals have been detected in sediment and water samples from Dicks Creek. Exceedence of OEPA guidelines for metals in water samples (Se, Pb and Zn) has been limited to samples collected only in 1995. Exceedence of SQGs for metals in sediment samples has been limited to samples collected in June of 2000, for Cd and Zn only which exceeded lower threshold levels (e.g., ERL). High hardness (350 – 800 CaCO₃ mg/L range) in Dicks Creek likely render the metals unavailable to organisms.
- VOCs and SVOCs do not exceed water or sediment quality guidelines. Due to their volatile nature and relative low toxicity, VOCs and SVOCs are not deemed a problem in Dicks Creek.
- Low level pesticides were detected in water samples in 1995 and in sediment samples in 1995 and 1997, however, were found to exceed water quality guidelines in 1995 only. Pesticides are not as persistent as PCBs and are likely only a pulse exposure issue during runoff events in late Spring and early Summer.
- Total PAHs detected in sediments were below consensus based SQGs. A few individual PAHs (i.e, fluorene, phenanthrene, fluoranthrene, benzo(b)fluoranthrene and benzo(a)anthracene) in sediments collected from the mouth of the landfill tributary only were found to exceed consensus based SQGs in 1995 and 1997.
- Total PCB and Aroclor concentrations exceeded not only SQGs, but also human health related USEPA guidelines in both sediments and water. Each year, PCB contamination appears to have spread to lower reaches of the creek due to the natural migration of

sediments. The concentrations of PCBs detected in sediments exceeded conservative water and sediment benchmark values by an order of magnitude or more on numerous occasions.

Assessment Endpoints

Assessment endpoints are "explicit expressions of the actual environmental value that is to be protected, operationally defined by an ecological entity and its attributes (USEPA, 1997, 1998). In order to bring focus to the assessment, endpoints should be as specific as possible and focus on distinct components of the ecosystem that could be adversely affected due to contaminants at the site. These endpoints are ecological measurable entities expressed in terms of individual organisms, populations, communities or ecosystems with some common characteristics (e.g., feeding preferences and habitat preferences). The assessment endpoints for this ERA were selected to include direct exposure to PCBs in Dicks Creek from water and sediments via ingestion and indirect exposure via the food chain. Because PCBs are known to bioaccumulate, and tissue residue data for a number of species were available, indirect exposure at various levels of the food chain were included in the model for assessment of risk at higher trophic levels. The assessment endpoints that were selected for Dicks Creek are:

- Benthic community structure as a food source for local fish and wildlife
- Protection and maintenance (survival, growth, and reproduction) of local fish (forage, omnivorous, and piscivorous)
- Protection and maintenance (survival, growth, and reproduction) of local insectivorous birds
- Protection and maintenance (survival, growth, and reproduction) of local waterfowl
- Protection and maintenance (survival, growth, and reproduction) of local piscivorous birds
- Protection and maintenance (survival, growth, and reproduction) of local wildlife

Measurement Endpoints

Measurement endpoints provide the actual measurements used to characterize ecological risk and are selected to represent mechanisms of toxicity and exposure pathways. Measurement endpoints generally include measured or modeled concentrations of chemicals in water, sediment, fish, birds, invertebrates and/or mammals, laboratory toxicity studies, *in situ* toxicity studies and field observations. The measurement endpoints identified for the ERA are:

- 1) Benthic and fish community metrics;
- 2) *In situ* and laboratory assay toxicity (survival) and bioaccumulation (tissue residues);
- 3) Measured and modeled tissue concentrations of PCBs in receptors vs. exceedence of

- effect-level thresholds;
- 4) Exceedence of water quality criteria and SQGs; and
- 5) Field measurements and observations.

Receptors of Concern

Risks to the environment were evaluated for individual receptors of concern that were selected to be representative of various feeding preferences, predatory levels, and habitats (aquatic, wetland, shoreline). The ERA does not characterize injury to, impact on, or threat to every species of plant or animal that lives in or adjacent to Dicks Creek; such a characterization is beyond the scope of this ecological risk assessment. The following receptors of concern were selected for the ERA:

Aquatic Invertebrates

- Oligochaete (*Lumbriculus variegatus*)
- Midge (*Chironomus tentans*)
- Mayfly (*Hexagenia* sp.)
- Bivalve (*Corbicula* sp.)

Aquatic crustacean

- Crayfish (*Orconectes* sp.)

Semi-aquatic Amphibian

- Green frog (*Rana clamatans*)

Fish Species

- White Sucker (*Catostomus commersoni*)
- Channel Catfish (*Ictalurus punctatus*)
- Common Carp (*Cyprinus carpio*)

Birds

- Tree swallow (*Tachycineta bicolor*)
- Mallard (*Anas platyrhynchos*)
- Belted kingfisher (*Ceryle alcyon*)
- Great blue heron (*Ardea herodias*)

Mammals

- Raccoon (*Procyon lotor*)

This ERA was intended as a screening level assessment. Therefore, all receptors were not evaluated, and a full characterization of magnitude, frequency, and duration of exposure was not conducted. However, the extent of the screening level assessment was extensive, since a large amount of field exposure and effects data was incorporated into a comprehensive, weight of evidence evaluation. *scope?*

Exposure Characterization

Approach

The Exposure Assessment is component of the analysis phase that ideally estimates the magnitude, frequency and duration of a stressor with one or more ecological components. The exposure can be expressed as the co-occurrence, or contact, in space and time of the stressor and the receptor. The exposure assessment delineates complete exposure pathways to calculate the degree of bioavailability, bioaccumulation/bioconcentration, and biomagnification from uptake through all pathways to which the receptors of concern are exposed (e.g., dermal, ingestion). This is accomplished via estimation of existing (empirical) data or estimation from models. Information derived from the exposure assessment is used in risk characterization.

The exposure analysis was based on empirical data collected during the study period on various fractions of sediment (whole sediment, surficial sediment, pore water), surface water, and tissues (indigenous species and caged surrogate species). Tissue concentrations from *in situ* assays using caged surrogate species are presented in the Effects Characterization Section. A description of the sediment and water concentrations of the chemicals organisms are exposed to in the study area are presented above in the Chemicals of Potential Concern Section. Overall, sediment concentrations of PCBs appear to be declining since (Tables 11,12). *?* However, as discussed above PCB concentrations are still at high levels. Data from 1999 and 2000 were used for modelling calculations in order to obtain accurate estimates of expected tissue concentrations and daily doses of total PCBs for receptors in the Dicks Creek food web (Fig. 5).

Sediments, water (including surface and/or pore), and contaminated prey were considered as the sources of PCBs to the aquatic food web. Specific measurement receptors that were evaluated in the analysis include: 1) benthic infaunal invertebrates represented by the oligochaete, *Lumbriculus variegatus*, 2) epibenthic invertebrates represented by the midge, *Chironomus tentans*, 3) sediment-associated emergent insects represented by the mayfly,

particularly *Hexagenia limbata*, 4) omnivorous fish species including the channel cat, *Ictalurus punctatus*, the white sucker *Catostomus commersoni*, and the common carp, *Cyprinus carpio*, and 5) piscivorous birds represented by the belted kingfisher, *Ceryle alcyon*. These receptors are expected resident species in Dicks Creek and have been recently observed by WSU and other investigators (OEPA, 1997).

Modelling Approach

The following sections summarize the results of the modeled exposure analysis for selected measurement receptors in the Dicks Creek food web. Tissue concentrations and daily doses of total PCBs were estimated using appropriate modelling approaches. Multiple modelling methods were used and compared to *in situ* exposed (caged and indigenous species) tissue concentrations. The model estimates of PCB concentrations in tissues, therefore, represent levels that would be expected in indigenous organisms. An important concern was the potential for magnification of errors as COPC levels are estimated at the next highest trophic level. Therefore, measured concentrations of total PCBs in the sediments and tissues of invertebrates and fish sampled from Dicks Creek were used in calculations wherever possible. In addition, tissue residue data, if available for a receptor, were compared to the results of calculations to insure that estimated body burdens were accurate. This use of empirical data was critical to the reduction of uncertainty at the bottom of the food chain.

One method used in the exposure assessment to determine bioaccumulation was based on the toxicokinetic model of Thomann (1981):

$$C_{org} = [(k_u \cdot C_w) + (CAE \cdot IR \cdot C_{food})] / k_e \quad (1),$$

where,

- C_{org} = concentration of total PCBs in the receptor organism ($\mu\text{g/g}$ wet weight)
- C_w = concentration of total PCBs in the water (surface or pore) ($\mu\text{g/L}$)
- C_{food} = concentration of total PCBs in the food item(s) of the receptor ($\mu\text{g/g}$)
- k_u = uptake rate coefficient of PCBs by the receptor (L water/g organism/d)
- k_e = elimination rate coefficient for PCBs from the receptor (1/d)
- CAE = chemical assimilation efficiency of the receptor (unitless), and
- IR = ingestion rate of receptor (g/g bw/d).

This model was modified to account for a receptor's ability to digest and assimilate food by incorporating a species' food assimilation efficiency (FAE, unitless) into equation (1):

$$C_{org} = [(k_u \cdot C_w) + (CAE \cdot IR \cdot FAE \cdot C_{food})] / k_e \quad (2).$$

Literature values for the parameters k_u , k_e , CAE, IR, and FAE were obtained for each receptor wherever possible. If more than one value for a given parameter was found, the values were averaged to obtain a mean value.

Relationships that describe the partitioning of an organic compound between sediments, food, or water and organisms were also used to estimate the concentration of total PCBs in a receptor. These include the bioaccumulation factor (BAF), the biota-sediment accumulation factor (BSAF), and the bioconcentration factor (BCF). The assumptions of such models are that the tissue concentrations are at steady-state with environmental concentrations and, for PCBs, that the contaminants are not metabolized. The bioaccumulation factor (BAF) is determined by the following equation:

$$BAF = C_{org,ss} / C_{s \text{ or } f} \quad (3),$$

where,

$C_{org,ss}$ = steady-state tissue concentration of contaminant in the receptor organism (mg/kg wet weight), and

$C_{s \text{ or } f}$ = concentration of contaminant in the sediments or food (mg/kg dry weight).

The biota/sediment accumulation factor (BSAF) is mathematically similar to the BAF (eq. 3), but it is calculated as the quotient of the lipid-normalized, steady-state tissue concentration in an organism and the organic-carbon normalized sediment concentration of a contaminant:

$$BSAF = C_{org,ss} / C_{s, oc} \quad (4),$$

$C_{l,ss}$ = steady-state tissue concentration of contaminant in the receptor organism normalized to lipid content (mg/kg lipid), and

$C_{s, oc}$ = concentration of contaminant in the sediments normalized to organic carbon content (mg/kg OC).

The bioconcentration factor (BCF) of a compound from water is calculated by the following relationship:

$$BCF = C_{org,ss}/C_w \quad (5),$$

where

$C_{org,ss}$ = steady-state tissue concentration of contaminant in the receptor organism (mg/kg wet weight), and

C_w = concentration of contaminant in surface or pore water (mg/L).

By rearranging the terms in equations (3)-(5), the steady-state tissue concentrations of a contaminant in a receptor can be estimated using measured sediment, food or water contaminant levels and BAFs, BSAFs or BCFs reported in the literature.

Exposure Predictions

Concentrations of total PCBs in sediment, water column, *in situ* exposure water, and pore water in 1999 and 2000 were used for calculations of exposure (Tables 11,12). Tissue levels of PCBs measured in *in situ*-exposed organisms are also summarized in Tables 11 and 12. Ohio EPA (OEPA) conducted tissue analysis of PCBs in fish collected in 1996 and 1998 and the data are summarized in Table 13. Specifically, data from samples collected at Amanda were used because total PCBs were highest in the sediments and waters from this site. Levels of PCBs measured in biota from both *in situ* toxicity tests and the sampling of indigenous macroinvertebrates and fish by WSU and Ohio EPA were used in the calculations for omnivorous and piscivorous receptors (Tables 11,13). Equations used to estimate PCB daily dose and tissue concentrations for the belted kingfisher are more complex and are described below. Assumptions in addition to those outlined above are reported below and all parameter values obtained from the literature, calculations, and results are provided in Appendix A. The key receptors for which the most data was available are modeled below.

1. Exposure of Benthic Infaunal Invertebrates: *Lumbriculus variegatus*, *Oligochaeta*

In 1997, WSU observed *L. variegatus* tissue levels for total PCBs of 19,000 µg/kg wet weight following an *in situ* exposure in the Landfill Tributary. WSU observed levels of total PCBs in indigenous oligochaetes at the same site of 8333 µg/kg wet wt. Downstream of the Landfill Tributary, in 1999, WSU observed *L. variegatus* tissue levels at Amanda that ranged from 57.9 - 344 µg/kg wet wt or 7718 - 55521 µg/kg lipid following 4-d *in situ* sediment exposures. *L. variegatus* tissue levels at the Beaver Dam (BD) site resulting from this study ranged from 103 - 266 µg/kg wet wt or 12093 - 70118 µg/kg lipid. In June 2000, WSU observed *L. variegatus*

tissue levels at Amanda that ranged from 26.1 - 677 µg/kg wet wt or 5217 - 130116 µg/kg lipid. *L. variegatus* tissue levels at USGS were 353.6 - 1470, µg/kg wet wt or 20803 - 94223 µg/kg lipid (Table 11).

L. variegatus is a deposit-feeding organism. For the modelling of *L. variegatus* tissue levels of PCBs, it was assumed that uptake of PCBs occurs from pore water and ingested sediments. Therefore, in the equations, the pore water and sediment concentrations of total PCBs are used for C_w and C_{food} , respectively. Parameter values for k_u , k_e , and IR were oligochaete-specific values obtained from the literature. CAE and FAE values obtained from the literature were general to benthic and aquatic invertebrates.

The estimated tissue concentration of total PCBs in *L. variegatus* using eq. (2), pore water and sediment data from 1999, and mean parameter values as input was 1003 µg/kg wet wt. Using pore water and sediment data from 2000 this value was 8170 µg/kg wet wt.

Because uptake rate constants for PCBs from sediments to oligochaetes (k_s , g sediments/g organism/d) were available, a more simplistic toxicokinetic model was used to provide another estimate of PCB bioaccumulation:

$$C_{\text{org}} = [(k_u \cdot C_w) + (k_s \cdot C_s)] / k_e \quad (6),$$

where k_u , C_w , and k_e are as in eq. (1), k_s is as defined above, and C_s is the concentration of PCBs in sediments (µg/g dry wt).

The estimated tissue concentration of total PCBs in *L. variegatus* using eq. (6), pore water and sediment data from 1999, and mean parameter values (i.e., rate constant; k_u , k_s , k_e) as input was 1314 µg/kg wet wt. Using pore water and sediment data from 2000, the estimate was 8268 µg/kg wet wt.

The lipid-normalized BAF-based estimates (eq. 3) of PCB bioaccumulation by oligochaetes ranged from 554-9401 µg/kg lipid in 1999 and from 175 - 2959 µg/kg lipid in 2000.

Therefore, the exposure analysis for benthic infaunal invertebrates, represented by *Lumbriculus variegatus*, resulted in accurate estimates of total PCBs that would be expected to accumulate in this sediment-associated receptor. BAF-based predictions of PCB bioaccumulation were within the range of lipid-normalized PCB levels measured in both indigenous and experimental oligochaetes used in field tests, but at the lower end of this range. All calculations and parameter values with citations are shown in Appendix A.

2. Benthic Invertebrates: *Chironomus tentans*, Diptera

WSU measured the tissue concentrations of PCBs in *C. tentans* following 4-d *in situ* exposures carried out in June, 2000. Chironomids exposed in against the sediment (AS) chambers accumulated 94.34 $\mu\text{g/kg}$ wet wt, or 3134 $\mu\text{g/kg}$ lipid. *C. tentans* exposed in surficial sediment (SS) chambers bioaccumulated 7435 $\mu\text{g/kg}$ wet wt, or 189665 $\mu\text{g/kg}$ lipid.

C. tentans is an epibenthic, tube building, detritus grazer and it was assumed that uptake of PCBs occurs from pore water and ingested sediments. Therefore, in the exposure modelling, the pore water and sediment concentrations of total PCBs are used for C_w and C_{food} , respectively. Parameter values for k_u , k_e , and IR were specific to *C. tentans* and other midge species and were obtained from the literature. CAE and FAE values obtained from the literature were generic for all benthic and aquatic invertebrates, including midges.

The estimated tissue concentration of total PCBs in *C. tentans* was 116 $\mu\text{g/kg}$ wet wt using eq. (2), pore water and sediment data from 1999, and mean parameter values as input. Using pore water and sediment data from 2000, the estimate was 1,001 $\mu\text{g/kg}$ wet wt.

Using the BSAF values for chironomids listed in Appendix A to calculate total tissue PCBs (eq. 4) provided estimates ranging from 1,690 – 549,043 $\mu\text{g/kg}$ lipid and 532 – 173,022 $\mu\text{g/kg}$ lipid, based on 1999 and 2000 levels of PCBs in the sediments at Amanda, respectively. Similarly, the lipid-normalized BAF-based estimates (eq. 3) of PCB bioaccumulation by chironomids ranged from 1,306 – 15,742 $\mu\text{g/kg}$ lipid in 1999 and from 411 – 4,955 $\mu\text{g/kg}$ lipid in 2000. The BCF-based model of total tissue PCBs in *C. tentans* yielded predicted ranges of 115 – 1,534 $\mu\text{g/kg}$ wet wt and 1,001 – 13,192 $\mu\text{g/kg}$ wet wt for 1999 and 2000, respectively.

Therefore, all models provided accurate predictions of tissue concentrations measured in field-exposed chironomids. The BSAF approach provided the closest agreement between predicted and measured tissue PCBs. All calculations and parameter values with citations are shown in Appendix A.

3. Emergent Insects: The Mayfly, Ephemeroptera

The mayfly was chosen as a measurement receptor in the Dicks Creek food web because as a sediment-associated, emergent insect, it serves as a prey item for upper trophic level organisms such as amphibians and birds. Although numerous mayfly species have been collected from Dicks Creek (OEPA, 1997), no measured body burdens of PCBs have been reported. Therefore, expected tissue concentrations in mayflies were predicted using multiple modelling approaches and then compared to tissue residue levels reported in the literature.

Concentrations of PCBs in mayfly tissues reported in the literature ranged from 3.09 - 315 $\mu\text{g/kg}$ on a wet weight basis. (Gobas *et al.*, 1989; Drouillard *et al.*, 1996; Corkum *et al.*, 1997; Baron *et al.*, 1999). The lipid-normalized range was 218.9 - 16057 ng PCB/g lipid (Drouillard *et al.*, 1996; Corkum *et al.*, 1997).

Investigations of PCB bioaccumulation by Great Lakes mayflies have shown that uptake from surface water is negligible and that ingested sediments are the primary sources to the mayfly (Gobas *et al.*, 1989). Therefore, in the exposure modelling, sediment concentrations of total PCBs are used for C_{food} , and surface and pore water concentrations are not considered. Parameter values for k_s (uptake rates constant for PCBs from sediments; g sediment/g organism/d), k_e , and IR were specific to mayflies and were obtained from the literature (Appendix A). CAE and FAE values obtained from the literature were generic for all benthic and aquatic invertebrates.

The estimated tissue concentration of total PCBs in mayflies using eq. (2), sediment data from 1999 and mean parameter values as input was 80.38 $\mu\text{g/kg}$ wet wt. Using the sediment data from 2000, the estimate was 25.3 $\mu\text{g/kg}$ wet wt. BAF-based estimates (eq. 3) of PCB bioaccumulation by mayflies ranged from 9.22 - 251 $\mu\text{g/kg}$ wet wt in 1999 and from 29.29 - 799 $\mu\text{g/kg}$ wet wt in 2000. Therefore, the ingestion (eq. 2) and the BAF (eq. 3) models estimated expected tissue concentrations similar to the range reported in the literature. Both models provided the very close agreement between predicted and measured concentrations of PCBs

bioaccumulated by mayflies. All calculations and parameter values with citations are shown in Appendix A.

4. Omnivorous fish: Demersal Species (*Ictalurus punctatus*, channel cat; *Cyprinus carpio*, common carp; *Catostomus commersoni*, white sucker)

Omnivorous fish such as the channel cat, the common carp and the white sucker forage in the sediments and were chosen as a measurement receptor based on their presence and because of the availability of measured concentrations of PCBs in fish collected from Dicks Creek (OEPA, 1997). The mean (\pm 1SD) tissue concentrations of PCBs in fish collected from Dicks Creek were 0.464 ± 0.221 , 9.53 ± 14.72 and 3.01 ± 1.68 mg/kg wet wt, for channel cat, common carp and white sucker, respectively (Table 13). OEPA did not provide data for lipid levels, therefore, lipid-normalized concentrations of the OEPA data were calculated by using average lipid values obtained from the literature (Appendix A) for the three omnivorous fish species considered in this ERA. The lipid-normalized concentrations of the OEPA (1997) tissue data ranged from 4.1 - 489 mg PCBs/kg lipid, with a mean (\pm 1 SD) over all species of 5.1 ± 9.5 mg PCBs/kg lipid.

The assumptions for the modelling of omnivorous, demersal fish in Dicks Creek were that uptake of PCBs occurs from PCBs in the surface water, and from ingestion of contaminated benthic invertebrates and sediments. Dietary data for catfish and the amount of sediments in the gut contents of white sucker and other sediment-associated species were obtained from the literature and used to determine the proportional contribution of PCBs from ingested receptor invertebrates (*L. variegatus*, *C. tentans*, mayflies; Appendix A). Because avian piscivores, such as the belted kingfisher, prefer fish of approximately 11-13 cm length (Kelly, 1996), gut content data for fish <30 cm was selected for the diet analysis. In the equations, the surface water and sediment concentrations of total PCBs measured at Amanda are used for C_w and C_{food} , respectively. Parameter values for k_u and k_e from various fish species were obtained from the literature. CAE and FAE values obtained from the literature were generic for all fish, including benthivorous species. IR rates for catfish were available in the literature. All parameter values and citations are provided in Appendix A.

Based on surface water, sediment and invertebrate tissue data collected by WSU in 1999, the estimated concentration was 2.86 mg PCBs/kg wet wt in fish using eq. (2) with mean parameter values as input. Using the data from 2000, the estimate was 1.57 mg/kg wet wt. BAF-based

estimates ranged from 0.09 - 221.2 mg PCB/kg lipid and the BSAF model estimated tissue concentrations ranging from 5.12 - 203.7 mg PCBs/kg lipid.

The bioconcentration (BCF) model (eq. 5) was modified for estimating the concentration of PCBs in omnivorous fish at trophic level (TL) 3 with the food chain multiplier (USEPA, 1999a):

$$C_{org} = BCF \cdot FCM \cdot C_w \quad (7),$$

where FCM is the food chain multiplier (unitless). FCM values for TL3 species accumulating Aroclors 1248 and 1254 were obtained from published reports (USEPA, 1999a; Sample et al., 1997). Based on channel cat BCFs obtained from the literature, tissue concentrations are expected to range from 1.42 - 27.5 mg/kg wet wt. These values were in close agreement with PCB concentrations in the tissue of fish collected from Dicks Creek (0.22 - 26.5 mg/kg wet wt) by OEPA (1997).

Overall, the modified Thomann model (eq. 2), BAF-, BSAF-, and BCF-based equations accurately predicted expected PCB concentrations in demersal species inhabiting Dicks Creek. Since the fish tissue data was not collected or analyzed by WSU, it was important to evaluate the small data set with multiple modelling approaches. It is our conclusion that the OEPA fish data is accurate and thus represents expected levels of fish contamination by PCBs present in Dicks Creek. All calculations and parameter values with citations are shown in Appendix A.

5. Piscivorous Birds: Belted Kingfisher (*Ceryle alcyon*)

The belted kingfisher, *Ceryle alcyon*, is a representative of the fourth trophic level in the Dicks Creek conceptual model (Figure 5) and thus is at the top of the food chain. In Ohio, this species has been observed to eat a nearly exclusive diet of fish (USEPA, 1993). Dietary doses of PCBs to the kingfisher, and tissue concentrations of PCBs expected in belted kingfisher from consuming contaminated fish were calculated using methods described in USEPA (1997; 1999a) and are described below. Fish tissue levels of PCBs reported by OEPA (1997) were used to drive the equations. Because the home range of kingfishers in Ohio is approximately 0.61 km of shoreline (USEPA, 1993), three iterations of calculations were performed for each estimate to satisfy assumptions of 10, 50, and 100% foraging time spent in contaminated sites along Dicks Creek. IR values for the belted kingfisher were obtained from the Wildlife Exposure Factors Handbook (USEPA, 1993) and all predator uptake of PCBs was assumed to be from ingestion of contaminated fish (*i.e.*, water and sediment ingestion were not considered).

Daily dietary dose of PCBs in belted kingfishers inhabiting Dicks Creek were estimated using a modification of general equations outlined in USEPA (1997). The formula is as follows:

$$DD = IR \cdot C_f \cdot P_f \cdot F_f \quad (8),$$

where:

- DD = Daily dose of PCBs ingested (mg PCBs/kg bw/d)
- IR = Ingestion rate (kg/kg bw/d)
- C_f = PCB concentration in fish food items (mg PCBs/kg wet wt)
- P_f = Proportion of fish in diet that are contaminated (unitless; set to 0.10, 0.50, or 1.0 during iterations)
- F_f = Fraction of total diet consisting of fish (unitless; 0.86, (USEPA, 1993)).

Using OEPA (1997) fish contamination data to calculate the ranges of expected DD in the belted kingfisher resulted in the following. When 100% of ingested fish were assumed to be contaminated (P_f), DD ranged from 0.09 - 39.9 mg/kg bw/d. When P_f was set to 50% and 10%, the ranges were 0.05 - 19.9 and 0.01 - 3.99 mg/kg bw/d. The 50th percentile DDs to kingfishers reported in Moore et al., (1999) ranged from 0.07 - 0.33 mg/kg bw/d. Therefore, the DD calculations outlined above were accurate for kingfishers. Due to the lack of other streams with riparian zone habitats nearby to Dicks Creek, we expect resident belted kingfishers to forage between 50 -100% of the time in Dicks Creek, and thus their DDs are expected to be above the reported 50th percentile values (Moore et al., 1999).

The expected PCB tissue concentrations in kingfishers were calculated based on equation 5-13 in USEPA (1999a). This equation relied on the use of FCMs for the kingfisher at TL 4 and its prey items (i.e., fish at TL 3). Because the majority of PCB isomers measured in the tissues of invertebrates by WSU were those with log K_{ow} values between 4-7, FCMs for compounds of this partitioning range were used in calculations and were obtained from USEPA (1999a). Because Aroclors 1248 and 1254 are commonly measured by USEPA and OEPA, the FCMs for these PCB mixtures, reported Sample et al., (1997), were also used. The relationship is as follows:

$$C_{bkf} = C_f \cdot (FCM_{TL4} / FCM_{TL3}) \cdot P_f \cdot F_f \quad (9),$$

where:

- C_{bkf} = PCB concentration in the belted kingfisher (mg/kg fresh wt)
- C_f = PCB concentration in fish food items (mg PCBs/kg wet wt)

- FCM_{TL4} = Food chain multiplier for the belted kingfisher of trophic level 4 (unitless)
 FCM_{TL3} = Food chain multiplier for prey items (*i.e.*, fish) of trophic level 4 (unitless)
 P_f = Proportion of fish in diet that are contaminated (unitless; set to 0.10, 0.50, or 1.0 during iterations)
 F_f = Fraction of total diet consisting of fish (unitless; 0.86, (USEPA, 1993)).

Using OEPA (1997) fish contamination data was used to estimate PCB concentrations in the tissues of belted kingfishers resulted in the following. When the assumption of 100% contamination of the fish diet was input to the model, the ranges of tissue concentrations were 0.32 - 15.2 mg total PCBs/kg fresh wt, 0.66 - 13.52 mg Aroclor 1248/kg fresh wt, and 0.72 - 14.75 mg Aroclor 1254/kg fresh wt. When P_f was set to 50%, the ranges were 0.16 - 7.61 mg total PCBs/kg fresh wt, 0.33 - 6.76 mg total Aroclor 1248/kg fresh wt, and 0.36 - 7.38 mg Aroclor 1254/kg fresh wt. When P_f was set to 10%, the estimates resulted in ranges of 0.03 - 1.52 mg total PCBs/kg fresh wt, 0.07 - 1.35 mg total Aroclor 1248/kg fresh wt, and 0.07 - 1.47 mg Aroclor 1254/kg fresh wt.

Concentrations of PCBs levels in the tissues of piscivorous birds have been reported in the literature. Jarman *et al.* (1996) reported levels of total PCBs in the common Murre (*Uria aalge*) of 5.9 mg/kg dry wt. Total PCBs in sea birds, raptors and herons were reported to range from 0.02 - 105 mg/kg fresh wt (Boumphrey *et al.*, 1993). Zimmermann *et al.* (1997) reported a maximum concentration of a single PCB isomer of 26 mg/kg lipid, which would equate to 2.22 mg/kg bw assuming an average lipid content of birds of 8.9% (van Wezel *et al.*, 2000). The estimated concentrations in belted kingfishers from eq. (9) are in very close agreement with reported literature values for other piscivorous species exposed to dietary PCBs. All calculations and parameter values with citations are shown in Appendix A.

Effects Characterization

Approach

In the Effects Assessment portion of the ERA, organism responses are evaluated. Multiple approaches were used to assess whether adverse biological effects exist in the aquatic ecosystem of Dicks Creek. These included comparisons to water and sediment quality criteria/guidelines, in-stream community surveys of benthic macroinvertebrates and fish following OEPA and ASTM methods, laboratory toxicity and bioaccumulation testing using ASTM and USEPA test methods, *in situ* assays of toxicity and bioaccumulation, tissue analyses

of indigenous benthic macroinvertebrate and fish species, and modelling. Water and sediment chemistry collected by WSU, USEPA and OEPA were compared to published sediment and water quality guidelines and criteria (SQGs and WQCs). Using this screening approach, exceedances of quality criteria suggest that the potential exists for impacts to aquatic and benthic populations (see above Chemicals of Potential Concern Section). In the modelling of risk (*i.e.* HQs), TRVs were compared to tissue concentrations of surrogate test species and key resident receptor species. ? estimating

TRVs were selected based on Lowest Observed Adverse Effects Levels (LOAELs) and/or No Observed Adverse Effects Levels (NOAELs) from laboratory and/or field-based studies reported in the scientific literature. These TRVs examine the effects of PCBs and dioxin-like PCB isomers on the survival, growth, and reproduction of fish and wildlife species in Dicks Creek. Reproductive effects (*e.g.*, egg maturation, egg hatchability, and survival of juveniles) were generally the most sensitive endpoints for animals exposed to PCBs. Toxicity endpoints and TRVs were obtained for PCBs from the literature and from the USEPA's Hudson River ERA document currently under peer-review (USEPA, 1999b). The toxicity endpoints and their values are shown in Tables 14-17. TRVs obtained from Sample *et al.* (1997) and USEPA (1999b) were as follows: 1) NOAEL and LOAEL for PCBs in the brown bullhead, *Ictalurus nebulosus*, (a catfish) from laboratory studies were 1.5 and 1.7 mg/kg wet wt, respectively, 2) NOAEL and LOAEL for PCBs in the belted kingfisher were 0.01 and 0.07 mg/kg/d, respectively, 3) NOAEL-based benchmark for Aroclor 1242 in the belted kingfisher was 0.41 mg/kg/d, and 4) NOAEL and LOAEL benchmarks for Aroclor 1254 in the belted kingfisher were 0.18 and 1.8 mg/kg/d, respectively. Toxicity endpoints and TRVs were used in quotient methods that describe the risk to receptors in the Dicks Creek food web. The significance of the predicted tissue levels and TRV comparisons are discussed in the Risk Characterization Section below.

Surveys of Benthic Macroinvertebrate and Fish Communities

In the OEPA 1995 biological water quality study of the Great Miami River and its tributaries (OEPA, 1997), non-attainment status was reported at all of the sampling locations surveyed in Dicks Creek due to poor and very poor macroinvertebrate (Invertebrate Community Index – ICI) and fish (Index of Biotic Integrity – IBI) criterion. Macroinvertebrate communities throughout Dicks Creek were severely impacted and exhibited low diversity in which only pollution tolerant species were found. ICI scores ranged from 6 to 12. The Great Miami River at the mouth of

Dicks Creek (RM 47.6) showed a slight depression in the macroinvertebrate community with reduced community density, increased tolerant species and the presence of blue-green algae (ICI 40, vs. 44 at RM 47.7). Poor community performance was attributed to severe impacts resultant of various AK Steel discharges (OEPA, 1997).

Prior to a spill of flushing liquor from outfall 003 (RM 3.80) on 26 July, 1995, fish communities performed in the fair to good range (IBI = 28-43, Modified Index of Well Being = 4.4-9.7) downstream of the North Branch of Dicks Creek. Scores from RM 3.0 downstream were significantly below expected biological criterion with ratings of Very Poor to Fair. The spill resulted in a massive fish kill that extended from outfall 003 to the confluence of the Great Miami River and resulted in a further degraded fish community (IBI decreased from 30 to 22). A total of 22 species of fish (174 fish) were collected at RM 0.4 prior to the spill and only two species (three individual fish) were observed afterwards (OEPA, 1997). This is the most recent IBI and ICI community index conducted to date.

WSU conducted a qualitative survey of the benthic macroinvertebrates using both a sediment core sampler and a Surber sampler (3.5 square ft. area) during the summer of 2000. During the June sampling period, no benthic invertebrates could be recovered at the USGS site with sediment core sampling. Only 1 leech (Hirudinea) and 3 caddisfly (Trichoptera) larvae were recovered with the Surber sampler. At the Amanda site core sampling recovered one leech, and numerous dead *Corbicula fluminea* (Asian clam) were observed. The surber sampler recovered many chironomids (Chironomidae) and caddisfly (Trichoptera), 1 riffle beetle (Coleoptera), 4 mayfly (Ephemeroptera), 1 isopod (Isopoda), and a few *Corbicula fluminea*.

In the August, 2000 sampling no organisms were recovered with the core sampler. The Surber sampler also did not recover any organisms at the USGS site. However, at Amanda the Surber recovered: 3 leeches, many chironomids, small *Corbicula* and caddisfly (2 species), and 1 mayfly and beetle. Again, many dead adult *Corbicula* were noted. A Surber sampling at TodHunter Road recovered: many flatworms (Turbellaria), 2 isopods and amphipods, and 1 crayfish, mayfly and caddisfly.

The WSU sampling results were similar to those of earlier OEPA studies that used artificial substrates (Hester-Dendy) as samplers. Both studies show the benthic macroinvertebrate

communities are of poor quality, with very low densities, pollution tolerant organisms, and evidence of high clam mortality.

Qualitative Observations of Habitat and Wildlife

The macrohabitat was evaluated at six sampling stations with Qualitative Habitat Evaluations Index (QHEI) scores ranging from 72.5 near the mouth to 40 at RM 3.0 indicating fair habitat quality over all (Appendix G) (OEPA 1987). Habitat quality improves downstream of Yankee Road (RM 2.4) where the stream canopy returns, riparian zone diversity increases, and riffle areas increase. This area of improved habitat was the primary focus of the study and included the WSU sites of Amanda, USGS and Beaver Dam. QHEI scores generated from a survey conducted by Wright State University in 2000 were higher than OEPA, indicating a possible difference due to the evaluator's judgement of QHEI scoring. The WSU scores were as follows: Little Sugar Creek reference (at Swigert Rd), 115; Todhunter reference, 102; Amanda (RM 1.63), 100; and USGS (RM 2.45) 81. Given the size of the drainage area, high flows often exist following rain events. Large grained sediments (e.g., sand) dominate in Dicks Creek and the sediment bottom has been observed to be unstable, moving after runoff events. In addition, a fine layer of fine grained sediments (e.g., clay, silt, organic matter) settles on most sediment surfaces and high turbidity is noted during high flows. *In situ* cages quickly became covered with a fine layer of sediment even during low flow conditions. PCBs and nonpolar chemicals tend to bind strongly and concentrate in small grained sediments, which are readily transported downstream during high flows.

Mammals observed in or beside the creek (within riparian zone) include white tail deer, and signs of opossum and racoons. A dead snapping turtle was recovered near the Beaver Dam site. Small green frogs were seen on the banks edge. A bird count was conducted (15 minutes/site/2 observers) in August, 2000. The following birds were sighted:

Todhunter: Mourning Dove (14), American Robin (3), Purple Finch (21), American Crow (2), Canada Geese (54), European Starling (164), Killdeer (2), Tufted Titmouse 91), Field Sparrow (1);

Dicks Creek, upstream of confluence with North Branch: Mallard (12), American Goldfinch (2), Mourning Dove (1), House Sparrow (20), Northern Cardinal (1);

Landfill Tributary: Belted Kingfisher (2), Great Blue Heron (1), American Goldfinch (9), Carolina Chickadee (5), Baltimore Oriole (2), Blue-Gray Gnatcatcher (2), Gray Catbird (1), Hairy Woodpecker, Mallard (2);

USGS: Mourning Dove (5), American Crow (1), European Starling (6), Tufted Titmouse (2), Belted Kingfisher (2);
Amanda: Tufted Titmouse (1), Carolina Chickadee (2).

In Situ and Laboratory Evaluations of Toxicity and Bioaccumulation

Organisms for *in situ* studies were exposed in flow-through chambers for 2 to 10-days while placed against surficial sediments, in the water column, in chambers filled partially with surficial sediment and water, and in chambers filled with pore water from deeper sediments (1-8 cm depth). In the laboratory, short-term assessments of organism mortality were conducted for 2 to 10 days using *Daphnia magna*, *Pimephales promelas*, *Hyalella azteca* and *Chironomus tentans*, following modified American Society for Testing and Materials (ASTM) and U.S. Environmental Protection Agency (USEPA) methods. In addition, bioaccumulation was assessed *in situ* using *Lumbriculus variegatus*, *H. azteca* and *C. tentans* and in the laboratory using *L. variegatus* for 2 d to 4 wks.

The test sites for *in situ* exposures in 1998 through 2000 were at reference sites (Elk Creek, Caesar Creek, Little Sugar Creek, Dicks Creek upstream of the confluence with the North Branch (RM 5.26), USGS (RM 2.45), Beaver Dam (RM 2.36) and/or Amanda (RM 1.63).

The sites on Dicks Creek that were below the effluent outfalls of AK Steel (*i.e.*, USGS RM 2.45, Beaver Dam RM 2.36 and Amanda RM 1.63) were acutely toxic. In 1998 there was no survival of amphipods or midges in surficial sediment exposures at Amanda (Figure 6). In 1999, survival was also low in sediment and pore water exposures at the Beaver Dam site and Amanda (Figure 7); however survival was good in the water column or in chambers separated from the sediment with mesh (Against Sediment treatment). Sediments collected during *in situ* exposures showed PCB contamination increasing downstream, being highest at Amanda at 625 µg/kg (Figure 8). *L. variegatus* tissue concentrations of PCBs were also highest at Amanda in *in situ* exposures (Figure 9) and highest in surficial sediment exposures. Oligochaete and midge tissue isomer patterns and relative magnitudes were similar to waters from exposure chambers with the tetra- isomer region being the highest in concentration (Figures 10-12). The amphipods accumulated less PCB than the oligochaete as would be expected based on its life history and feeding characteristics (Figure 13). Laboratory whole sediment assays were much less sensitive than *in situ* exposures and showed the Beaver Dam to be more toxic than Amanda (Table 18). This reversal in response pattern was matched with higher PCB

concentrations in the Beaver Dam sediments subsampled from the laboratory assay (Fig 14) and oligochaete tissue accumulation (Figure 15), suggesting PCBs as the causative agent.

In addition, indigenous bivalves (*Corbicula*) collected from RM 2.45 (USGS) and RM 1.63 (Amanda) in August of 2000 yielded total tissue body burdens from 684.6 to 1648.2 µg/kg, respectively. Whole body tissue residues of this level have generally been observed in fish tissue which are a trophic level above *Corbicula*. Indigenous worms (oligochaete) collected from the landfill tributary area in 1997 yielded total tissue body burdens of 8,333 µg/kg.

The USGS site proved to be the most toxic, with sediment contact again causing the highest mortality (Figure 16). Survival at Amanda ranged from good to poor in near sediment exposures. Also, as in previous studies, survival was good in the water column. Overall, survival was worse than in 1999. Again, previous year patterns were repeated in regards to laboratory responses being less sensitive than *in situ* exposures (Table 19). Organism responses *in situ* matched PCB concentrations with the highest levels occurring at USGS (Figure 17), while in June, Amanda was highest (Figure 18). It is interesting to note that concentrations at USGS were similar in June and August, but Amanda concentrations decreased in August (Figure 17). The same trend was seen in August with *in situ* exposures. Those organisms in contact with sediments showed poorer survival. Survival was also poorer at USGS than Amanda (Figure 16). The laboratory responses were minimal, with acute toxicity observed in *D. magna* at USGS (57.5% survival) and midge survival at Amanda (70%) (Table 20). Again PCB isomer patterns were similar to previous years with tetra-chlorinated isomers being highest in concentration (Figures 19-22). As in 1999, highest mortality was observed in *in situ* chamber treatments from which the chamber water concentrations of PCBs were highest (Figure 23).

The *in situ* sediment exposures significantly reduced survival at sites with PCB contamination (low mg/Kg concentrations). Adverse effects were observed *in situ* with sediment PCB concentrations as low as 133 µg/Kg PCB. In general, the highest mortality was associated with organism exposures *in situ* to surficial sediments and/or pore waters where PCB concentrations were higher. There were several statistically significant correlations ($r^2 = 0.98-0.99$) between organism (*D. magna*, *H. azteca*, *C. tentans*, *P. promelas*) survival and PCB concentrations in the surficial sediment exposures (Table 21). *In situ* survival was better correlated with PCB concentrations measured inside the exposure chambers, than with concentrations outside the

chambers. In summary, for *in situ* exposures, organism response (e.g., mortality) and tissue concentrations increased with increasing PCB contamination of sediments with statistically significant correlations.

Survival in laboratory, whole sediment assays tended to be better than *in situ* exposures to pore water or containing sediments, but worse than water column or against sediment exposures for *H. azteca* and *C. tentans*. This is likely a result of the reduced exposure to sediments in these 2 later *in situ* exposures. In addition, PCB concentration trends observed from laboratory sediments did not match *in situ* results suggesting that *in situ* studies are more accurate.

There were significant correlations between PCBs sediment and tissue concentrations and organism survival in multi-year evaluations. PCB isomer patterns in tissues of exposed organisms (*L. variegatus* and *H. azteca*) were similar to those found in sediments at the same sites. In 1999 and 2000, the tetra- isomers were at the highest concentrations in *L. variegatus* (~375 µg/kg tissue in 1999 and 68 µg/kg tissue in 2000). Total PCBs in *L. variegatus* tissues exposed for 4 days in the laboratory were ~ 1000 µg/kg while *in situ* concentrations were up to ~356 µg/kg in surficial sediment exposures. The amphipod, *H. azteca*, however showed an isomer pattern shift in 1999 towards the penta- and hexa- range maximums. Concentrations in sediments, waters and tissues in June and August 2000 were lower than in previous years, yet still exceeded water and sediment guidelines and biological effect thresholds.

These field and laboratory results implicate PCBs as the COPC and likely causing significant ecological risk to organisms associated with the creek, as shown in the ERA food web assessment.

Risk Characterization

Approach

Risk Characterization examines the likelihood of adverse ecological effects occurring as a result of exposure to chemicals and discusses the qualitative and quantitative assessment of risks to ecological receptors with regard to toxic effects. Risks are estimated by comparing the results of the Exposure Characterization (measured or modeled concentrations of chemicals where receptors reside and within receptors of concern) to adverse effect levels, such as performance criteria for toxicity assays (i.e., 80% survival, LC50s, NOAELs, LOAELs), critical tissue levels,

or water and sediment quality guidelines/criteria that are biologically based. For example, the TRVs used in the modelling of risk are compared to exposure concentrations. The ratio of these two numbers is called a Hazard Quotient (HQ). Sediment Toxicity Quotients (STQ) are ratios of the sediment concentration observed to the SQG. While exceedance of a SQG denotes risk, the STQ suggests the magnitude of the risk if the STQ is greater than one. In addition, the benthic and fish community indices utilized by OEPA as biological criteria demonstrate if adverse effects are occurring. By comparing these various biological responses with the concentrations of the COPCs, indications of causality can be established. This evidence is strengthened when tissue concentrations of the COPCs are also linked to adverse effects, as exposure and uptake is verified.

HQs and STQs equal to or greater than one typically are considered to indicate potential risk to ecological receptors, for example reduced or impaired reproduction or recruitment of new individuals. These quotients provide insight into the potential for adverse effects upon individual animals in the local population resulting from chemical exposure. If a HQ suggests that effects are not expected to occur for the average individual, then they are probably insignificant at the population level. However, if a quotient indicates risks are present for the average individual, then risks may be present for the local population.

At each step of the risk assessment process there are sources of uncertainty. Measures were taken in the ERA to address and characterize the uncertainty. Uncertainty in the ERA was evaluated further by comparisons of various ERA model assumptions and approaches commonly found in the peer-reviewed literature. In addition, multiple iterative calculations using the full range of parameter values found in the literature were carried out to determine the range of expected daily doses and tissue concentrations of PCBs. These ranges are shown in Appendix A.

To estimate potential ecological risk, a hazard quotient (HQ) was calculated for each measurement receptor. An HQ is determined as follows (USEPA, 1999a):

$$HQ = EEL / TRV \quad (10),$$

where:

HQ = Hazard quotient (unitless)

- EEL = PCB estimated or expected exposure level (mass PCB/mass tissue or mass daily dose PCBs ingested/mass bw/d)
- TRV = PCB toxicity reference value (mass PCB/mass tissue or mass daily dose PCBs ingested/mass bw/d).

Risk Predictions

By comparing the sediment concentrations of the site contaminants with various SQGs as a STQ, relative risk was determined. The SQGs are frequency based thresholds of biological effects. If the value of STQ exceeds one then adverse effects are likely. There were no SQGs for total PAH where the STQs exceeded 1 in the mainstem of Dicks Creek. There was a TEL-based STQ of 2.1 that occurred in the Landfill tributary in 1997 (Table 2). However, for individual PAHs, the SLC- and TEL- based SQGs had several STQs exceeding one and up to 43.5 for fluoranthene at the USGS site (Tables 3,4). Fluoranthene can cause photo-induced toxicity in the presence of solar ultraviolet wavelengths (sunlight) at low part-per-billion levels in water. The SQGs do not account for this phototoxicity phenomenon, unfortunately. However, the USGS site has little sunlight during the summer period due to a thick riparian canopy of trees. For metals, STQs slightly exceeded 1 for Zn and Cd (Tables 6,7) at threshold effect levels (adverse effects possible) in 2000. However, for PCBs, there were numerous STQs that exceeded 1 at the threshold effect concentrations (up to 49 for SLCs). At the midrange effect levels, the Amanda site had a STQ of 1.04 for the MEC guideline. Using Aroclor guidelines the STQs ranged to 285 for Extreme Effect Concentrations from the OEPA data. These STQs suggest a high probability for adverse benthic biota effects from PCBs.

EELs for oligochaetes, midges, mayflies, omnivorous fishes, and the belted kingfisher are taken from measured values or from estimates described in the Exposure Characterization Section and in Appendix A. Toxicity endpoints and reported TRVs that were used in calculations are listed in Tables 14-17 and were previously discussed in the Effects Characterization Section. The results of HQ determination are shown in Appendix A, and will be summarized below.

HQs for *L. variegatus* and *C. tentans* (benthic invertebrates) are shown in Appendix A. Because toxicity endpoints and TRVs were not available for *C. tentans*, the values specific to *L. variegatus* were used to calculate the risk to midges. HQs based on mortality and weight loss LOAEL and NOAEL body burdens for both oligochaetes and midges were below 1.0. This suggests that PCBs in Dicks Creek would not adversely affect the growth and survival of these

organisms, however the HQs do not provide an estimation of the risk for other sublethal effects such as reproduction. Based on modelling predictions, PCB exposure in Dicks Creek was not expected to pose lethal hazard to these benthic species, however, acute toxicity was observed *in situ*. In addition, their rapid uptake of PCBs makes them a key vector of contamination to higher trophic position predators.

HQs for mayflies are shown in Appendix A. Because toxicity endpoints and TRVs were not available for mayflies, the values specific to *L. variegatus* were used to calculate the risk to these emergent insects. As observed for *L. variegatus* and *C. tentans*, all HQs calculated for mayflies, based on mortality and weight loss LOAEL and NOAEL body burdens, were below 1.0. This suggests that PCB contamination in Dicks Creek would not adversely affect the growth and survival of these organisms, but no information is provided for other effects such as emergence success or reproduction. While the model may predict that emergent mayflies could have viable populations in Dicks Creek, they would also serve as a vector of PCB contamination to insectivorous species including some amphibians and birds.

HQ calculations for fish are shown in Appendix A. Due to the availability of published toxicity endpoints and TRVs for either total PCBs or Aroclor 1254, both types of values were used in the calculations. OEPA fish data on tissue concentrations of PCBs were also used. When concentrations that represent LD100 values (complete mortality) in lake trout and chinook salmon were used to calculate the HQ, the results were values of 0.67 and 1.41, respectively. This suggests that omnivorous fish species foraging within highly contaminated areas of Dicks Creek (e.g., Amanda, USGS Gauge, Landfill Tributary) would be at risk of bioaccumulating a lethal amount of PCBs. In addition, when the lowest reported NOAELs and LOAELs for mortality and reproductive effects (expressed as mg PCB/kg fish wet wt) were used in HQ calculations, values >1.0 were frequently the result. Finally, when the field-based TRV for PCBs, reported for the brown bullhead catfish (USEPA, 1999b), was used in HQ calculations the value was >3.0. The majority of the HQ calculations used to characterize risks to omnivorous, sediment-associated fish species predict that members of this ecologically important guild would be severely impacted by current PCB contamination. This would be especially true for fish in early and sensitive life stages.

HQ calculations for the belted kingfisher are shown in Appendix A. The highest and lowest estimated Daily Dietary Doses of PCBs that resulted from each set of exposure calculations

(i.e., assumptions of 10, 50 and 100% contamination of ingested fish) were used with the TRVs and with toxicity endpoints (NOAELs and LOAELs for reproduction) in HQ determinations. In all cases, the HQs resulting from use of the highest predicted tissue concentration of PCBs were much greater than 1.0, and ranged from 2.22 – 3,990. Using the lowest predicted tissue PCB concentrations from the exposure assessment resulted in some HQs exceeding 1.0, with a range from 0.006 - 9.46. However, none of the HQs based on lowest daily dietary doses and NOAEL and LOAEL values for reproduction were greater than 1.0. Overall, the risk characterization for belted kingfishers in Dicks Creek suggests that resident mating pairs, which have been observed by WSU, would be at risk high for deleterious reproductive and acute effects, including death. This conclusion even applies to birds that were considered to spend only 10% of their time foraging in Dicks Creek.

PCB concentrations at the Landfill tributary (RM 2.71) (1999) and at Amanda (RM 1.63) and USGS (RM 2.45) sites consistently exceeded water and SQGs and were elevated in tissues of resident fish and benthic macroinvertebrates. Total PCB sediment concentrations at Amanda and USGS (2000) ranged from 130 to 200 µg/Kg, exceeding lower threshold effect levels. Aroclor concentrations at the Landfill Tributary and downstream in 1999 exceeded Extreme Effect Levels. Total PCB levels PCB Aroclors in Dicks Creek have been found at levels exceeding not only SQGs, but also human health related USEPA guidelines in both sediments and water. Each year, PCB contamination has spread to lower reaches of the creek due to the natural migration of sediments. The concentrations of PCBs detected in sediments collected from Dicks Creek by researches from both OEPA and Wright State University were found to exceed conservative water and sediment benchmark values by an order of magnitude or more in most on numerous occasions.

Metals are elevated, however the high hardness levels in Dicks Creek suggests they may only be a concern when hardness levels decrease, such as during a runoff event. PAHs occur in Dicks Creek and in tissues of organisms there, but do not exceed SQGs or WQCs. However, in the presence of UV light, PAHs can be photoactivated and produce toxicity even at low part per billion levels (e.g., Hatch and Burton 1998). Therefore, metals and PAHs may also be contributing to some degree to adverse biological effects, in addition to the PCBs. Their contribution to stress in the ecosystem is less than PCBs, as evidenced by the conclusions of each assessment method.

The indigenous biota (benthic macroinvertebrates and fish) are of poor quality (despite reasonable habitat quality), and thus reflect the SQG prediction of adverse effects occurring. In addition, the acute toxicity observed *in situ*, particularly in association with sediment exposures, confirms the predictions of the SQGs that adverse effects should be occurring. The elevated PCB levels in organisms exposed to the sediments document exposure and also suggest a causality link with acute mortality and depressed biotic indices.

This risk characterization has focused on recently collected data. However, these same adverse effects have been observed every year that surveys have been conducted, suggesting a long term problem has existed that likely has had far reaching impacts on the local and downstream ecosystems.

Conclusions

On-Site Contamination

A multi-faceted, weight of evidence assessment was conducted on the ecological risk occurring at Dicks Creek. Each assessment method (e.g., toxicity, biological surveys, chemistry, modelling) has inherent strengths and limitations. It is only possible to reduce many of the potential uncertainties of each method by integrating the assessment with other approaches, as done in this project. Often times, ecological evaluations of contamination have confounding results, where some component of the assessment produces conclusions that do not support another component. In these cases, a WOE approach is useful, where the preponderance of data is used for the final conclusion of whether significant contamination is occurring. This particular evaluation was unique, however, as each line of evidence arrived at the same conclusion.

The SQGs are one of the most common assessment methods used for determining whether significant sediment contamination exists and determining which chemicals are of concern. The SQGs used for evaluating the significance of PCB contamination in this study are widely used throughout North America. They are empirically based, where massive databases of paired chemistry and biological effect data have been compared. These criteria have been found to be very reliable as predictors of adverse biological effects (e.g., McDonald et al 2000). The lack of significant exceedances of any chemicals besides PCBs is somewhat surprising, given the nature of the watershed. While metals are elevated, the extremely high hardness occurring in Dicks Creek reduces their biological availability. Organisms are exposed to PAHs that may be

causing stress when in the presence of sunlight. This phenomenon, known as photo-induced toxicity, can be toxic at levels observed in Dicks Creek during low flow conditions when the water is clear and there is adequate sunlight (solar ultraviolet radiation). Therefore, metals and PAHs may also be contributing to some degree to adverse biological effects.

The concentrations of PCBs present and the correlations noted between PCB presence, uptake, and toxicity suggest it is clearly the dominant stressor in the Dicks Creek ecosystem. The exceedance of PCB SQG values suggests adverse conditions exist in Dicks Creek due to PCBs. The modeled predictions suggest harm will occur to organisms in higher trophic levels that feed on contaminated lower trophic level benthic invertebrates. These receptors of concern occur at Dicks Creek. The habitat of Dicks Creek in the study area downstream of the Landfill Tributary is reasonably good. There is a good riparian zone with a lot of edge habitat allowing for a high diversity of birds and small mammals to exist. Despite the reasonable habitat, the benthic and fish community surveys are of poor quality. The laboratory and *in situ* toxicity assays show acute toxicity exists and the tissue concentrations of organisms exposed to Dicks Creek show only PCB concentrations are elevated. *The weight of evidence firmly establishes causality, linking extreme adverse effects of biota associated with Dicks Creek to PCB contamination.*

Off-Site Contamination Potential

Given the size of the drainage area, high flows often exist following rain events. Large grained sediments (e.g., sand) dominate in Dicks Creek and the sediment bottom has been observed to be unstable, moving after runoff events. In addition, a fine layer of fine grained sediments (e.g., clay, silt, organic matter) settles on most sediment surfaces and high turbidity is noted during high flows. PCBs and nonpolar chemicals tend to bind strongly and concentrate in small grained sediments, which are readily transported downstream during high flows. These characteristics suggest Dicks Creek is a relatively dynamic system, where sediments (particularly small grained sediments) are readily transported downstream. This also suggests that the PCB contamination observed in surficial sediment is both recent and has a tendency to be moved downstream of the study area to the Great Miami River.

Recommendations

The conclusions from this ERA and the multi-year surveys of Dicks Creek clearly demonstrated that this ecosystem is severely impacted and poses a continuing threat to organisms that interact with it. The dynamic nature of this stream is driven by its hydrology and morphology. Since it drains a large watershed and is channelized, it is subject to high flows with high associated stream power. These conditions flush small grained sediments and associated organic matter downstream. Given the tendency for chemical binding to sediments and their propensity for movement downstream, it is likely that current surficial sediment contamination is of relatively recent origin, or is continual seeping in from subsurface sources. While PCB concentrations in surficial sediments show a general trend of declining, they still exceed adverse effect levels. In addition, high levels of metals and PAHs may be contributing to environmental impacts and it is unknown whether these contaminants are decreasing through time. Given these characteristics of Dicks Creek, it is recommended that a program for continued biological and chemical monitoring be established. The monitoring program should measure the primary stressors in surface waters and sediments, assess the incidence of upwelling or downwelling zones in the stream (to define the role of groundwater contamination), and monitor key components of the aquatic ecosystem food web, including indigenous community structure, toxicity, and bioaccumulation. This monitoring should define the extent of spatial contamination from the confluence of the North Branch to the mouth of Dicks Creek. Only with this information can valid assessments of ecosystem quality and recovery be made, leading to sound management decisions on restoration.

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TABLES

Table 1: Sediment Quality Guideline (SQG) Descriptions^a

Acronym	Approach	Threshold Effect Concentration SQGs	Description	Reference
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Threshold effect concentration (TEC)

LEL	SLCA	Lowest Effect Level	Sediments are considered clean to marginally polluted . No effects on the majority of sediment-dwelling organisms are expected below this concentration.	Pesaud <i>et al.</i> (1993)
TEL	WEA	Threshold effect Level	Represents the concentration below which adverse effects are expected to occur only rarely.	Smith <i>et al.</i> (1996)
ERL	WEA	Effect range - Low	Represents the chemical concentration below which adverse effects would be rarely observed	Long and Morgan (1991)
MET	SLCA	Minimal effect threshold	Sediments are considered clean to marginally polluted . No effects on the majority of sediment-dwelling organisms are expected below this concentration.	EC and MENVIQ (1992)

Probable effect concentration (PEC)

SEL	SLCA	Severe effect level	Sediments considered to be heavily polluted. Adverse effects on the majority of sediment-dwelling organisms are expected when this concentration is exceed.	Perasud <i>et al.</i> (1993)
PEL	WEA	Probable effect level	Represents the concentration above which adverse effects are expected to occur frequently	Smith <i>et al.</i> (1996)
ERM	WEA	Effect range - medium	Represents the chemical concentration above which adverse effects would frequently occur	Long and Morgan (1991)
TET	SLCA	Toxic effect threshold	Sediments considered to be heavily polluted. Adverse effects on sediment-dwelling organisms are expected when this concentration is exceeded.	EC and MENVIQ (1992)
NEC		No effect concentration		
EEC		Extreme effect concentration		

^aMacDonald, D.D. et al. 2000. Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. Arch. Environ. Contam. Toxicol. 39:20-31

Table 2: Sediment Quality Guidelines (SQGs) for Total PAHs^a

(ug/g - ppm)

WSU Sediment Samples, June/August, 2000

	Sed Total ug/g (ppm)	TOC Norm ug/g OC	Threshold effect conc.						Midrange effect conc.				Extreme effect conc.		
			SLC	TEL	ERL	LEL	MET	CB TEC 95% CI	NEC	PEL	ERM	CB MEC 95% CI	TET	SEL	CB EEC 95% CI
SQGs Total PAH			409	87	350			290 119-461		804	2358	682-2854			10,000
Amanda 6/00	0.264	6.208	0.001	0.003	0.001			0.001		0.000	0.000	0.00015			3E-05
Amanda 8/00	0.267	6.267	0.001	0.003	0.001			0.001		0.000	0.000	0.00015			3E-05
USGS 6/00	0.660	16.97	0.002	0.008	0.002			0.002		0.001	0.000	0.00037			7E-05
USGS 8/00	0.519	13.37	0.001	0.006	0.001			0.002		0.001	0.000	0.00029			5E-05
OEPA Land trib 6-2-99	18		0.045	0.211	0.053			0.063		0.023	0.008	0.0102			0.002
OEPA Land trib 5-28-97	181		0.444	2.085	0.518			0.626		0.226	0.077	0.1008			0.018

= Sediment Quality Guidelines (SQGs), CB = consensus based

Values below SQGs are Sediment Toxicity Quotients (STQs) = Measured Environ.Cond. (MEC)/SQG

^aSwartz, R. C. 1999. Consensus sediment quality guidelines for polycyclic aromatic hydrocarbon mixtures. *Environ. Toxicol. Chem.* 18(4): 780-787.

Table 3: Sediment Quality Guidelines (SQGs) for PAHs^a
(ug/g - ppm)

	Sed Total ug/g (ppm)	Sed TOC Norm ug/g OC	Threshold effect conc.						Midrange effect conc.				Extreme effect conc.		
			SLC	TEL	ERL	LEL	MET	CB TEC 95% CI	NEC	PEL	ERM	CB MEC 95% CI	TET	SEL	CB EEC 95% CI
SQGs PAHs															
Naphthalene			41.0	3.0	16.0					39.0	210.0				
Acenaphthylene			5.0	1.0	4.0					13.0	64.0				
Acenaphthlene			6.0	1.0	2.0					9.0	50.0				
Fluorene			10.0	2.0	2.0					14.0	54.0				
Phenanthrene			37.0	9.0	24.0					54.0	150.0				
Anthracene			16.0	5.0	9.0					24.0	110.0				
Fluoranthene			64.0	11.0	60.0					149.0	510.0				
Pyrene			66.0	15.0	66.0					140.0	260.0				
B(a)Anthracene			26.0	7.0	26.0					69.0	160.0				
Chrysene			38.0	11.0	38.0					85.0	280.0				
Benzo(b)fluor			32.0	7.0	32.0					71.0	188.0				
Benzo(k)fluor			28.0	6.0	28.0					61.0	162				
Benzo(a)pyrene			40.0	9.0	43.0					76.0	160.0				

= Sediment Quality Guidelines (SQGs), CB = consensus based

Values below SQGs are Sediment Toxicity Quotients (STQs) = Measured Environ. Cond. (MEC)/SQG

^aSwartz, R. C. 1999. Consensus sediment quality guidelines for polycyclic aromatic hydrocarbon mixtures. *Environ. Toxicol. Chem.* 18(4): 780-787.

Table 4: Sediment Quality Guidelines (SQGs) for PAHs^a

(ug/g - ppm)

WSU Sediment Samples from USGS June, 2000

	Sed Total ug/g (ppm)	Sed TOC Norm ug/g OC	Threshold effect conc.						Midrange effect conc.				Extreme effect conc.			
			SLC	TEL	ERL	LEL	MET	CB TEC 95% CI	NEC	PEL	ERM	CB MEC 95% CI	TET	SEL	CB EEC 95% CI	
SQGs PAHs			OEPA 6/2/199 9	OEPA 5-28-97												
Naphthalene	7.410		1.30	12.0												
Acenaphthylene	4.530			6.9												
Acenaphthlene	6.500															
Fluorene	9.340		8.50													
Phenanthrene	61		1.6	30.9												
Anthracene	19			14.3												
Fluoranthene	110		2.20	43.5												
Pyrene	88.53		1.80	29.3												
B(a)anthracene	54.80			11.2												
Chrysene	53		0.86	10.2												
Benzo(b)fluor	134		0.78	8.4												
Benzo(k)fluor			0.68	6.7												
Benzo(a)pyrene	74		0.69	8.0												
			18.4	181.4												

 = Sediment Quality Guidelines (SQGs), CB = consensus based

Values below SQGs are Sediment Toxicity Quotients (STQs) = Measured Environ. Cond. (MEC)/SQG

^aSwartz, R. C. 1999. Consensus sediment quality guidelines for polycyclic aromatic hydrocarbon mixtures. *Environ. Toxicol. Chem.* 18(4): 780-787.

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Table 5: Water Quality Criteria for Metals

OEPA Water samples collected 6/02/99

Sample	Land Trib Mouth
Hardness (mg/L)	371

Calculated values based on OEPA collected water samples:

	Calculated WQC (ug/L) Land trib		Measured value
	Chronic WQC	Acute WQC	Land Trib. (ug/L)
Cadmium	3.18	17.21	16
Copper	36.25	60.96	50
Lead	16.94	434.38	100
Nickel	478.00	4299.73	60
Silver	NO CRITERION	38.70	40
Zinc	321.89	355.38	200

For water hardness of 100 mg/L

	Calculated WQC (ug/L)	
	Chronic	Acute
Cadmium	1.1	3.9
Copper	12	18
Lead	3.2	82
Nickel	160	1400
Silver	0.12	4.1
Zinc	110	120

Source: EPA 440/5-86-001, Quality Criteria for Water

Equations used:

	Chronic	Acute
Cadmium	$\text{Exp}^{(0.7852(\ln H)-3.49)}$	$\text{Exp}^{(1.128(\ln H)-3.828)}$
Copper	$\text{Exp}^{(0.8545(\ln H)-1.465)}$	$\text{Exp}^{(0.9422(\ln H)-1.464)}$
Lead	$\text{Exp}^{(1.2661(\ln H)-4.661)}$	$\text{Exp}^{(1.266(\ln H)-1.416)}$
Nickel	$\text{Exp}^{(0.846(\ln H)+1.1645)}$	$\text{Exp}^{(0.846(\ln H)+3.3612)}$
Silver	No Equation	$\text{Exp}^{(1.72(\ln H)-6.52)}$
Zinc	$\text{Exp}^{(0.8473(\ln H)+0.7614)}$	$\text{Exp}^{(0.8473(\ln H)+0.8604)}$

Table 6: Sediment Quality Guidelines (SQGs) for metals^c

(mg/kg - ppm)

WSU Sediment Samples June, 2000

SQGs for Metals			Threshold effect conc.						Midrange effect conc.				Extreme effect conc.			
	Sed Total mg/kg		SLC	TEL	ERL	LEL	MET	CB TEC 95% CI	NEC	PEL	ERM	CB MEC 95% CI	TET	SEL	CB EEC 95% CI	CB PEC
Arsenic				5.9	33.0	6.0	7.0	9.79		17.0	85.0		17.0	33.0		33
Cadmium				0.596	5.0	0.6	0.9	0.99		3.53	9.0		3.0	10.0		4.98
Chromium				37.3	80.0	26.0	55.0	43.40		90.0	145.0		100.0	110.0		111
Copper				35.7	70.0	16.0	28.0	31.60		197.0	390.0		86.0	110.0		149
Lead				35.0	35.0	31.0	42.0	35.80		91.3	110.0		170.0	250.0		128
Mercury				0.174	0.15	0.2	0.2	0.18		0.486	1.3		1.0	2.0		1.06
Nickel				18.0	30.0	16.0	35.0	22.70		36.0	50.0		61.0	75.0		48.6
Zinc				123.0	120.0	120.0	150.0	121.00		315.0	270.0		540.0	820.0		459
USGS 6/00																
Arsenic	5.40			0.915	0.164	0.900	0.771	0.552		0.318	0.064		0.318	0.164		0.164
Cadmium	0.93			1.560	0.186	1.550	1.033	0.939		0.263	0.103		0.310	0.093		0.187
Chromium																
Copper	5.60			0.157	0.080	0.350	0.200	0.177		0.028	0.014		0.065	0.051		0.038
Lead	5.60			0.160	0.160	0.181	0.133	0.156		0.061	0.051		0.033	0.022		0.044
Mercury																
Nickel																
Zinc	209			1.699	1.742	1.742	1.393	1.727		0.663	0.774		0.387	0.255		0.455

= Sediment Quality Guidelines (SQGs), CB = consensus based

Values below SQGs are Sediment Toxicity Quotients (STQs) = Measured Environ. Cond. (MEC)/SQG

^cMacDonald, D.D. et al. 2000. Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. Arch. Environ. Contam. Toxicol. 39:20-31

Table 7: Sediment Quality Guidelines (SQGs) for metals^c

(mg/kg - ppm)

Ohio EPA sediment samples

	Sed Total mg/kg		Threshold effect conc.						Midrange effect conc.				Extreme effect conc.			
			SLC	TEL	ERL	LEL	MET	CB TEC 95% CI	NEC	PEL	ERM	CB MEC 95% CI	TET	SEL	CB EEC 95% CI	CB PEC
SQGs for Metals																
Arsenic				5.9	33.0	6.0	7.0	9.79		17.0	85.0		17.0	33.0		33
Cadmium				0.596	5.0	0.6	0.9	0.99		3.53	9.0		3.0	10.0		4.98
Chromium				37.3	80.0	26.0	55.0	43.40		90.0	145.0		100.0	110.0		111
Copper				35.7	70.0	16.0	28.0	31.60		197.0	390.0		86.0	110.0		149
Lead				35.0	35.0	31.0	42.0	35.80		91.3	110.0		170.0	250.0		128
Mercury				0.174	0.15	0.2	0.2	0.18		0.486	1.3		1.0	2.0		1.06
Nickel				18.0	30.0	16.0	35.0	22.70		36.0	50.0		61.0	75.0		48.6
Zinc				123.0	120.0	120.0	150.0	121.00		315.0	270.0		540.0	820.0		459
OEPA Land Trib Mouth 6/02/99																
Arsenic	0.00			0.000	0.000	0.000	0.000	0.000		0.000	0.000		0.000	0.000		0.000
Cadmium	8.10			13.591	1.620	13.500	9.000	8.182		2.295	0.900		2.700	0.810		1.627
Chromium	37.00			0.992	0.463	1.423	0.673	0.853		0.411	0.255		0.370	0.336		0.333
Copper	36.00			1.008	0.514	2.250	1.286	1.139		0.183	0.092		0.419	0.327		0.242
Lead	570.00			16.286	16.286	18.387	13.571	15.922		6.243	5.182		3.353	2.280		4.453
Mercury	0.00			0.000	0.000	0.000	0.000	0.000		0.000	0.000		0.000	0.000		0.000
Nickel	15.00			0.833	0.500	0.938	0.429	0.661		0.417	0.300		0.246	0.200		0.309
Zinc	4000			32.52	33.33	33.33	26.67	33.06		12.70	14.81		7.41	4.88		8.71

= Sediment Quality Guidelines (SQGs), CB = consensus based

Values below SQGs are Sediment Toxicity Quotients (STQs) = Measured Environ. Cond. (MEC)/SQG

^cMacDonald, D.D. et al. 2000. Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. Arch. Contam. Toxicol. 39:20-31

Table 8: Sediment Quality Guidelines (SQGs) for Total PCBs^b

(ug/kg drywt - ppb)

WSU Sediment Samples, June/August, 2000

			Threshold effect conc.						Midrange effect conc.				Extreme effect conc.			
	Sed Total ng/g (ppb)	Sed TOC Norm n/g OC	SLC	TEL	ERL	LEL	MET	CB TEC 95% CI	NEC	PEL	ERM	CB MEC 95% CI	TET	SEL	CB EEC 95% CI	
SQGs Total PCB			3	34	50	70	200	35	190	277	400	340	1000	5300	1600	
Amanda 6/00	198.16	4.651	66.05	5.83	3.96	2.83	0.99	5.66	1.04	0.72	0.50	0.58	0.20	0.04	0.12	
Amanda 8/00	133.00	2.485	44.33	3.91	2.66	1.90	0.67	3.80	0.70	0.48	0.33	0.39	0.13	0.03	0.083	
USGS 6/00	135.19	3.475	45.06	3.98	2.70	1.93	0.68	3.86	0.71	0.49	0.34	0.40	0.14	0.03	0.08	
USGS 8/00	147.05	1.810	49.02	4.33	2.94	2.10	0.74	4.20	0.77	0.53	0.37	0.43	0.15	0.03	0.09	

= Sediment Quality Guidelines (SQGs), CB = consensus based

Values below SQGs are Sediment Toxicity Quotients (STQs) = Measured Environ.Cond. (MEC)/SQG

^bMacDonald, D.D. et al. 2000. Development and evaluation of consensus-based effect concentrations for polychlorinated biphenyls. Environ. Toxicol. Contam. 18(5)1403-1423.


Table 9: Sediment Quality Guidelines (SQGs) for PCBs^b (Aroclors)

(mg/kg drywt - ppm)

Ohio EPA sediment samples

	Aroclor	Aroclor total mg/kg dry wt.	Threshold effect conc.						Midrange effect conc.				Extreme effect conc.			
			SLC	TEL	ERL	LEL	MET	CB TEC 95% CI	NEC	PEL	ERM	CB MEC 95% CI	TET	SEL	CB EEC 95% CI	
SQGs Aroclor																
1248						0.030	0.050	NA					0.600	1.500	NA	
1254						0.060	0.060	NA					0.300	0.340	NA	
1260						0.005	0.005	NA					0.200	0.240	NA	
Land Trib 6/98 OEPA	1248	5.13				171	103						285.0	3.42		
1,800 ds	1248	1.69				56.3	33.8						93.9	1.13		
2,100 ds	1248	4.36				145	87.2						242.2	2.91		
2,800 ds	1248	0.95				31.7	19						52.8	0.6		
1,200 ds	1248	2.79				93.0	55.8						4.7	1.9		

ds = downstream of landfill tributary

 = Sediment Quality Guidelines (SQGs), CB = consensus based

Values below SQGs are Sediment Toxicity Quotients (STQs) = Measured Environ. Cond. (MEC)/SQG

^bMacDonald, D.D. et al. 2000. Development and evaluation of consensus-based effect concentrations for polychlorinated biphenyls. Environ. Toxicol. Contam. 18(5)1403-1423.

Table 10: Sediment Quality Guidelines (SQGs) for PCBsb (Aroclors)

(mg/kg drywt - ppm)

Ohio EPA sediment samples

			Threshold effect conc.						Midrange effect conc.				Extreme effect conc.			
	Aroclor	Aroclor total mg/kg dry wt.	SLC	TEL	ERL	LEL	MET	CB TEC 95% CI	NEC	PEL	ERM	CB MEC 95% CI	TET	SEL	CB EEC 95% CI	
SQGs Aroclor																
1248						0.030	0.050	NA					0.600	1.500	NA	
Land Trib																
6-99 Mouth	1242	16.8				560	336						28.00	11.20		
3-99 200' us	1242	1.86				62	37.2						3.10	1.24		
4-99, Yankee Rd bridge	1242	1.4				46.7	28						2.33	0.93		
4-99 Main St. Bridge	1242	2.01				67	40.2						3.35	1.34		
5-97 Mouth	1242	32.3				1077	646						53.8	21.5		
6-96 Land trib	1242	45				1500	900						75.0	30.0		
Land Trib	1242	64				2133	1280						106.7	42.7		

= Sediment Quality Guidelines (SQGs), CB = consensus based

Values below SQGs are Sediment Toxicity Quotients (STQs) = Measured Environ. Cond. (MEC)/SQG

Table 11: WSU 1999 data for use in the ERA calculations

Total PCBs in field-exposed Lv				
corrected for background				
	WCC	AS	SS	PWC
	ng/g	ng/g	ng/g	ng/g
Caesar Ck	1.582	30.274	-1.911	-2.635
Confluence	0.776	5.998	12.8	1.494
Beaver Dam	125.778	103.158	266.448	105.21
Amanda	30.497	104.874	344.233	57.8873

Total Dioxin-like PCBs in field-exposed Lv				
corrected for background				
	WCC	AS	SS	PWC
	ng/g	ng/g	ng/g	ng/g
Caesar Ck	0.211	3.908	-1.461	-1.121
Confluence	-1.355	4.575	-0.782	-0.549
Beaver Dam	8.536	5.89	12.228	8.555
Amanda	1.156	4.865	20.507	3.662

Total PCBs in field-exposed Ha				
CORRECTED FOR BACKGROUND				
	WCC	AS	SS	PWC
	ng/g	ng/g	ng/g	ng/g
Caesar Ck	5.111	-0.295	-0.053	3.438
Confluence	0.784	11.623	10.775	0.218
Beaver Dam	0.567	26.931		
Amanda	0.86	40.811	61.376	78.837

Frac. lipids (wet wt. basis) in field-exposed Lv				
	WCC	AS	SS	PWC
	frac	frac	frac	frac
Caesar Ck	0.0055	0.0122	0.007	0.0127
Confluence	0.0047	0.0038	0.0043	0.0025
Beaver Dam	0.0048	0.0022	0.0038	0.0087
Amanda	0.0046	0.0062	0.0062	0.0075

Frac. lipids (wet wt. basis) in field-exposed Lv				
	WCC	AS	SS	PWC
	frac	frac	frac	frac
Caesar Ck	0.0055	0.0122	0.007	0.0127
Confluence	0.0047	0.0038	0.0043	0.0025
Beaver Dam	0.0048	0.0022	0.0038	0.0087
Amanda	0.0046	0.0062	0.0062	0.0075

Frac. lipids (wet wt. basis) in field-exposed Ha				
	WCC	AS	SS	PWC
	frac	frac	frac	frac
Caesar Ck	0.0013	0.0037	0.0032	0.0008
Confluence	0.0038	0.0025	0.0236	0.0026
Beaver Dam	0.0018	0.0073		
Amanda	0.0019	0.0087	0.0088	0.0051

AK5 041669

Table 11: cont.

Total Dioxin-like PCBs in field-exposed Ha				
CORRECTED FOR BACKGROUND				
	WCC	AS	SS	PWC
	ng/g	ng/g	ng/g	ng/g
Caesar Ck	0.741	-0.079	-0.162	0.487
Confluence	-0.035	1.412	2.089	-0.149
Beaver Dam	-0.025	6.214		
Amanda	0.032	4.937	1.184	9.805

Frac. lipids (wet wt. basis) in field-exposed Ha				
	WCC	AS	SS	PWC
	frac	frac	frac	frac
Caesar Ck	0.0013	0.0037	0.0032	0.0008
Confluence	0.0038	0.0025	0.0236	0.0026
Beaver Dam	0.0018	0.0073		
Amanda	0.0019	0.0087	0.0088	0.0051

SEDIMENTS:				
	Caesar Ck	Confluence	Beaver Da	Amanda
	ng/g	ng/g	ng/g	ng/g
Total PCBs	0	10.822	409.1603	628.844
Total Dioxin-lik	0	1.031	15.348	28.981

SEDIMENT TOC:				
	Caesar Ck	Confluence	eaver Da	Amanda
	frac	frac	frac	frac
		0.0597	0.0389	0.0426
		0.0597	0.0389	0.0426

Water samples Total PCBs					
	WCC	AS	SS	PWC	MW
	ng/g	ng/g	ng/g	ng/g	ng/g
Caesar Ck	0.000	0.000	0.000	0.000	0.014
Confluence	0.000	0.000	0.000	0.000	0.000
Beaver Dam	0.000	0.098	0.009	0.000	2.220
Amanda	0.035	0.000	0.018	0.050	0.228

Water samples Total DIOXIN-LIKE PCBs					
	WCC	AS	SS	PWC	MW
	ng/g	ng/g	ng/g	ng/g	ng/g
Caesar Ck	0.000	0.000	0.000	0.000	0.000
Confluence	0.000	0.000	0.000	0.000	0.000
Beaver Dam	0.000	0.000	0.000	0.000	0.025
Amanda	0.000	0.000	0.000	0.000	0.000

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Table 11: cont.

Lipid norm. Total PCBs in field-exposed Lv				
corrected for background				
	WCC	AS	SS	PWC
	ng/g lipid	ng/g lipid	ng/g lipid	ng/g lipid
Caesar Ck	287.63636	2481.4754	-273	-207.4803
Confluence	165.10638	1578.4211	2976.7442	597.6
Beaver Dam	26203.75	46890	70117.895	12093.103
Amanda	6629.7826	16915.161	55521.452	7718.3067

Lipid norm. Total Dioxin-Like PCBs in field-exposed Lv				
corrected for background				
	WCC	AS	SS	PWC
	ng/g lipid	ng/g lipid	ng/g lipid	ng/g lipid
Caesar Ck	38.363636	320.32787	-208.7143	-88.26772
Confluence	-288.2979	1203.9474	-181.8605	-219.6
Beaver Dam	1778.3333	2677.2727	3217.8947	983.33333
Amanda	251.30435	784.67742	3307.5806	488.26667

Lipid norm. Total PCBs in field-exposed Ha				
corrected for background				
	WCC	AS	SS	PWC
	ng/g lipid	ng/g lipid	ng/g lipid	ng/g lipid
Caesar Ck	3931.5385	-79.72973	-16.5625	4297.5
Confluence	206.31579	4649.2	456.5678	83.846154
Beaver Dam	315	3689.1781		
Amanda	452.63158	4690.9195	6974.5455	15458.235

Lipid norm. Total PCBs in field-exposed Ha				
corrected for background				
	WCC	AS	SS	PWC
	ng/g lipid	ng/g lipid	ng/g lipid	ng/g lipid
Caesar Ck	570	-21.35135	-50.625	608.75
Confluence	-9.210526	564.8	88.516949	-57.30769
Beaver Dam	-13.88889	851.23288		
Amanda	16.842105	567.47126	134.54545	1922.549

TOC-Normalized SEDIMENTS:				
	Caesar Ck	Confluence	Beaver Da	Amanda
	ng/g OC	ng/g OC	ng/g OC	ng/g OC
Total PCBs		181.273032	10518.2596	14761.5962
Total Dioxin-like		17.2696817	394.550129	680.305164

Table 12: WSU 2000 data for use in the ERA calculations

Total PCBs in field-exposed Lv				
corrected for background				
	WCC	AS	SS	PWC
	ng/g	ng/g	ng/g	ng/g
LSC	220.38	-13.588	6.149	-19.523
USGS	249.485	353.646	1469.872	536.342
Amanda	238.279	205.998	26.083	676.601

Frac. lipids (wet wt. basis) in field-exposed Lv				
	WCC	AS	SS	PWC
	frac	frac	frac	frac
LSC	0.0071	0.007	0.008	0.0063
USGS	0.0124	0.017	0.0156	0.0165
Amanda	0.0049	0.0068	0.005	0.0052

Total Dioxin-like PCBs in field-exposed Lv				
corrected for background				
	WCC	AS	SS	PWC
	ng/g	ng/g	ng/g	ng/g
LSC	5.711	0.013	1.567	-0.968
USGS	11.882	2.959	17.116	4.18
Amanda	4.279	0.682	-0.598	11.128

Frac. lipids (wet wt. basis) in field-exposed Lv				
	WCC	AS	SS	PWC
	frac	frac	frac	frac
LSC	0.0071	0.007	0.008	0.0063
USGS	0.0124	0.017	0.0156	0.0165
Amanda	0.0049	0.0068	0.005	0.0052

Total PCBs in field-exposed Ct				
CORRECTED FOR BACKGROUND				
	WCC	AS	SS	PWC
	ng/g	ng/g	ng/g	ng/g
LSC	-841.516	-245.352	-1150.985	-1146.87
USGS	-1138.83	94.342	7434.862	-879.749
Amanda	-1335.177	-246.034	-872.345	-1243.62

Frac. lipids (wet wt. basis) in field-exposed Ct				
	WCC	AS	SS	PWC
	frac	frac	frac	frac
LSC	0.0087	0.0068	0.0044	0.0046
USGS	0.0042	0.03	0.0392	0.0089
Amanda	0.0051	0.0063	0.0048	0.0051

Table 12: cont.

Total Dioxin-like PCBs in field-exposed Ct				
CORRECTED FOR BACKGROUND				
	WCC	AS	SS	PWC
	ng/g	ng/g	ng/g	ng/g
LSC	-62.562	-29.229	-65.988	-69.99
USGS	-66.624	27.145	618.734	-83.706
Amanda	-78.384	-66.188	-67.688	-76.386

Frac. lipids (wet wt. basis) in field-exposed Ct				
	WCC	AS	SS	PWC
	frac	frac	frac	frac
LSC	0.0087	0.0068	0.0044	0.0046
USGS	0.0042	0.03	0.0392	0.0089
Amanda	0.0051	0.0063	0.0048	0.0051

SEDIMENTS:			
	LSC	USGS	Amanda
	ng/g	ng/g	ng/g
Total PCBs	0.087	135.186	198.168
Total Dioxin-lik	0.002	5.282	11.490

SEDIMENT TOC:			
	LSC	USGS	Amanda
	frac	frac	frac
	0.0856	0.0389	0.0426
	0.0856	0.0389	0.0426

TOC-Normalized SEDIMENTS:			
	LSC	USGS	Amanda
	ng/g OC	ng/g OC	ng/g OC
Total PCBs	1.016	3475.219	4651.831
Total Dioxin-lik	0.023	135.784	269.718

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Table 12: cont.

Lipid norm. Total PCBs in field-exposed Lv				
corrected for background				
	WCC	AS	SS	PWC
	ng/g lipid	ng/g lipid	ng/g lipid	ng/g lipid
LSC	31039.437	-1941.143	768.625	-3098.889
USGS	20119.758	20802.706	94222.564	32505.576
Amanda	48628.367	30293.824	5216.6	130115.58

Lipid norm. Total Dioxin-Like PCBs in field-exposed Ct				
corrected for background				
	WCC	AS	SS	PWC
	ng/g lipid	ng/g lipid	ng/g lipid	ng/g lipid
LSC	-7191.034	-4298.382	-14997.27	-15215.22
USGS	-15862.86	904.83333	15784.031	-9405.169
Amanda	-15369.41	-10506.03	-14101.67	-14977.65

Lipid norm. Total Dioxin-Like PCBs in field-exposed Lv				
corrected for background				
	WCC	AS	SS	PWC
	ng/g lipid	ng/g lipid	ng/g lipid	ng/g lipid
LSC	804.3662	1.8571429	195.875	-153.6508
USGS	958.22581	174.05882	1097.1795	253.33333
Amanda	873.26531	100.29412	-119.6	2140

Lipid norm. Total PCBs in field-exposed Ct				
corrected for background				
	WCC	AS	SS	PWC
	ng/g lipid	ng/g lipid	ng/g lipid	ng/g lipid
LSC	-96725.98	-36081.18	-261587.5	-249319.1
USGS	-271150	3144.7333	189664.85	-98848.2
Amanda	-261799.4	-39053.02	-181738.5	-243846.3

AK5 041674

Table 12: cont.

Water samples Total PCBs						
	Surf Water	WCC	AS	SS	PWC	MW
	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g
LSC	0.000	0.007	0.002	0.000	0.000	0.002
USGS	0.026	0.175	3.271	0.371	0.592	
Amanda	0.019	0.026	0.026	0.081	0.073	1.987

Water samples Total DIOXIN-LIKE PCBs						
	Surf Water	WCC	AS	SS	PWC	MW
	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g
LSC	0.000	0.000	0.000	0.000	0.000	0.000
USGS	0.000	0.010	0.083	0.009	0.000	
Amanda	0.000	0.004	0.000	0.008	0.001	0.072

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Table 13: OEPA fish tissue PCB data.

OEPA fish data from Dicks Creek (demersal species only)

Lipid levels of demersal fish:

Year	Species	Total PCBs (ug/kg)	Total PCBs (ug/kg lipid) using mean lipid data from lit
1996	Channel Cat	620	18235.29
1998	Channel Cat	307	9029.41
1996	Carp	220	4059.04
1998	Carp	26500	488929.89
1998	Carp	1860	34317.34
1998	White Sucker	4190	64461.54
1998	White Sucker	1820	28000.00
<i>Mean Channel Cat</i>		463.50	13632.35
<i>Stdev Channel Cat</i>		221.32	6509.54
<i>Mean Carp</i>		9526.67	175768.76
<i>Stdev Carp</i>		14722.19	271627.16
<i>Mean White Sucker</i>		3005.00	46230.77
<i>Stdev White Sucker</i>		1675.84	25782.20
<i>Mean Overall</i>		5073.86	92433.22
<i>Stdev Overall</i>		9547.22	175970.00

Species	frac lipid	Citation
channel cat	0.0260	Gale et al., Environ. Sci. Technol. 31(1):178-187, 1997
channel cat	0.0380	Gale et al., Environ. Sci. Technol. 31(1):178-187, 1997
channel cat	0.0390	Gale et al., Environ. Sci. Technol. 31(1):178-187, 1997
channel cat	0.0300	Gale et al., Environ. Sci. Technol. 31(1):178-187, 1997
channel cat	0.0370	Gale et al., Environ. Sci. Technol. 31(1):178-187, 1997
<i>C. carpio</i>	0.0840	Gerstenberger, S. L. et al., Environ. Toxicol. Chem. 16(11):2222-2228,
<i>C. carpio</i>	0.0387	Hajslovia, J. et al., Environ. Contam. Toxicol. 59:452-459, 1997
<i>C. carpio</i>	0.0399	Hajslovia, J. et al., Environ. Contam. Toxicol. 59:452-459, 1997
white sucker	0.0800	Morrison et al., Environ. Sci. Technol. 31(11):3267-3273, 1997
white sucker	0.0500	Morrison et al., Environ. Sci. Technol. 31(11):3267-3273, 1997
<i>stdev channel cat</i>	0.0340	
<i>mean channel cat</i>	0.0057	
<i>mean carp</i>	0.0542	
<i>stdev carp</i>	0.0258	
<i>mean white sucker</i>	0.0650	
<i>stdev white sucker</i>	0.0212	

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Table 14: Toxicity Endpoints for invertebrates, *L. variegatus*

from Table 4-4 of USEPA Hudson River ERA

Toxicity Endpoints for Benthic Infaunal Invertebrates: Effective Concentrations of PCBs in *Lumbriculus variegatus*

Species	PCB	Exposure duration	Effect Level	Effect whole body conc. (mg/kg wet wt)	Effect Endpoint	Citation
<i>L. variegatus</i>	PCB 153	35 d	LOAEL	126	mortality	Fisher et al., Aquat. Toxicol. 45(2-3):115-126, 1999
<i>L. variegatus</i>	PCB 153	35 d	LOAEL	119	mortality	Fisher et al., Aquat. Toxicol. 45(2-3):115-126, 1999
<i>L. variegatus</i>	PCB 47	35 d	LOAEL	113	mortality	Fisher et al., Aquat. Toxicol. 45(2-3):115-126, 1999
<i>L. variegatus</i>	PCB 1	35 d	LOAEL	64	mortality	Fisher et al., Aquat. Toxicol. 45(2-3):115-126, 1999
			mean	105.50		
			stdev	28.17		
<i>L. variegatus</i>	PCB 153	35 d	NOAEL	65	mortality	Fisher et al., Aquat. Toxicol. 45(2-3):115-126, 1999
<i>L. variegatus</i>	PCB 153	35 d	NOAEL	63.1	mortality	Fisher et al., Aquat. Toxicol. 45(2-3):115-126, 1999
<i>L. variegatus</i>	PCB 47	35 d	NOAEL	49.3	mortality	Fisher et al., Aquat. Toxicol. 45(2-3):115-126, 1999
			mean	59.13		
			stdev	8.57		
<i>L. variegatus</i>	PCB 153	35 d	LOAEL	126	weight loss	Fisher et al., Aquat. Toxicol. 45(2-3):115-126, 1999
<i>L. variegatus</i>	PCB 153	35 d	LOAEL	119	weight loss	Fisher et al., Aquat. Toxicol. 45(2-3):115-126, 1999
<i>L. variegatus</i>	PCB 47	35 d	LOAEL	113	weight loss	Fisher et al., Aquat. Toxicol. 45(2-3):115-126, 1999
<i>L. variegatus</i>	PCB 1	35 d	LOAEL	64	weight loss	Fisher et al., Aquat. Toxicol. 45(2-3):115-126, 1999
			mean	105.50		
			stdev	28.17		
<i>L. variegatus</i>	PCB 153	35 d	NOAEL	65	weight loss	Fisher et al., Aquat. Toxicol. 45(2-3):115-126, 1999
<i>L. variegatus</i>	PCB 153	35 d	NOAEL	63.1	weight loss	Fisher et al., Aquat. Toxicol. 45(2-3):115-126, 1999
<i>L. variegatus</i>	PCB 47	35 d	NOAEL	49.3	weight loss	Fisher et al., Aquat. Toxicol. 45(2-3):115-126, 1999
			mean	59.13		
			stdev	8.57		

Reported Ranges of toxicity endpoints

LD₅₀ body conc. for mortality

Highest reported: Amphipod, *Gammarus pseudolimnaetus*, 2 mo. exposure, Aroclor 1248, LD₅₀ = 552 mg/kg wet wt, mortality, Nebeker and Puglisi, 1974

Lowest reported: Amphipod, *Hyalella azteca*, >or= 10 wk, PCB 52, LD₅₀ = 552 mg/kg wet wt, mortality, Nebeker and Puglisi, 1975

LOAEL

Highest reported: Amphipod, *Gammarus pseudolimnaetus*, 2 mo. exposure, LOAEL = 552 mg/kg wet wt, 50% red. reprod., Nebeker and Puglisi, 1974

Lowest reported: Grass shrimp, *Palaemonetes pugio*, 16 d, LOAEL = 27 mg/kg wet wt, 45% mortality, Nimmo et al., 1974

NOAEL

Highest reported: Amphipod, *Gammarus pseudolimnaetus*, 2 mo. exposure, NOAEL = 127 mg/kg wet wt, reprod., Nebeker and Puglisi, 1974

Lowest reported: Grass shrimp, *Palaemonetes pugio*, 16 d, NOAEL = 5.4 mg/kg wet wt, mortality, Nimmo et al., 1974

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Table 15: Toxicity Endpoints for fish

from Table 4-5 of USEPA Hudson River ERA

Toxicity Endpoints for Laboratory Fish: Effective Concentrations of PCBs and Aroclors

Species	PCB	Exposure duration	Effect Level	Effect whole body conc. (mg/kg wet wt)	Effect Endpoint
Lake trout	PCB 153	15 d	LD ₁₀₀	7.6	Fry mortality
Chinook salmon	PCB 153	15 d	LD ₁₀₀	3.6	Fry mortality
			Mean complete mortality	5.60	
			Stdev. complete mortality	2.83	
Adult fathead minnow	Aroclor 1254	9 mo	LOAEL	999	Adult mortality
Adult fathead minnow	Aroclor 1254	9 mo	LOAEL	429	Spawning
Adult minnow (<i>Phoxinus</i>)	Clophen A50	40 d	LOAEL	170	Egg hatchability
Brook trout fry	Aroclor 1254	118 d	LOAEL	125	Fry mortality
Brook trout fry	Aroclor 1254	21 d	EL-effect	32.8	Egg hatchability
Brook trout fry	Aroclor 1254	21 d	EL-effect	77.9	Egg hatchability
Juvenile spot	Aroclor 1254	20 d	LOAEL	46	Adult mortality
Adult pinfish	Aroclor 1216	42 d	LOAEL	42	Adult mortality
Killifish	PCB mixture	40 d	LOAEL	19	Adult mortality (f)
Lake trout fry	Aroclor 1254	48 d	EL-effect	4.5	Fry mortality
Killifish	PCB mixture	40 d	LOAEL	3.8	Egg prod. & food consump
			Mean, all effects data	177.18	
			Stdev. all effects data	298.77	
			Mean, all mortality data	205.92	
			Stdev. all mortality data	390.76	
			Mean, all reprod data	142.70	
			Stdev. all reprod data	171.96	
			Mean Aroclor 1254, all effects	244.89	
			Stdev. Aroclor 1254, all effects	362.21	
			Mean Aroclor 1254, mortality	293.63	
			Stdev. Aroclor 1254, mortality	472.90	
			Mean Aroclor 1254, reprod	179.90	
			Stdev. Aroclor 1254, reprod	216.90	
Adult fathead minnow	Aroclor 1242	9 mo	NOAEL	436	Adult mortality
Adult fathead minnow	Aroclor 1254	9 mo	NOAEL	429	Egg hatchability
Adult pinfish	Aroclor 1016	42 d	NOAEL	170	Adult mortality
Adult fathead minnow	Aroclor 1254	9 mo	NOAEL	105	Spawning
Brook trout fry	Aroclor 1254	118 d	NOAEL	71	Fry mortality
Juvenile spot	Aroclor 1254		NOAEL	27	Adult mortality
Adult minnow (<i>Phoxinus</i>)	Clophen A50	40 d	NOAEL	15	Egg hatchability
Killifish	PCB mixture	40 d	NOAEL	3.8	Adult mortality (f)
Killifish	PCB mixture	40 d	NOAEL	0.76	Egg prod. & food consump.
			Mean, all effects data	139.73	
			Stdev. all effects data	174.77	
			Mean, all mortality data	141.56	
			Stdev. all mortality data	176.48	
			Mean, all reprod data	137.44	
			Stdev. all reprod data	199.78	
			Mean Aroclor 1254, all effects	158.00	
			Stdev. Aroclor 1254, all effects	183.47	
			Mean Aroclor 1254, mortality	49.00	
			Stdev. Aroclor 1254, mortality	31.11	
			Mean Aroclor 1254, reprod	267.00	
			Stdev. Aroclor 1254, reprod	229.10	

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Table 16: Toxicity Endpoints for fish

from Table 4-6 of USEPA Hudson River ERA

Studies for which the only contaminants were PCBs (i.e., no other contaminants present) were used from Table 4-3

Field collected fish, most tests were embryo-larval stage

Toxicity Endpoints for Field-Collected Fish: Effective Concentrations of PCBs and Aroclors

Species	Field collection notes	PCB	Effect Level	Effect conc. (mg/kg wet or dry wt)	Biological matrix	Effect Endpoint
Winter flounder	Adult and eggs; N. Bedford Harbor	PCBs	EL-effect	39.6	eggs	Growth rate of larvae
Killifish	Fish; N. Bedford Harbor	PCBs	LOAEL	29.2	liver	Embryo and larval survival
Killifish	Fish; N. Bedford Harbor	PCBs	LOAEL	20.8	liver	Adult female mortality
Chinook salmon	Adult and eggs; L. Michigan	PCBs	EL-effect	2.75	eggs	Hatching success
Chinook salmon	Adult and eggs; L. Michigan	PCBs	EL-effect	5.75	eggs	Hatching success
English sole	Adult and eggs; Puget Sound	PCBs	LOAEL	2.56	liver	Production of normal larvae
Lake trout	Adult and eggs; Great Lakes	PCBs	EL-effect	0.25	eggs	Egg mort.; % normal fry hatching
Lake trout	Adult and eggs; Great Lakes	PCBs	EL-effect	7.77	eggs	Egg mort.; % normal fry hatching
<i>Mean, dry wt. data</i>				29.87		
<i>Stdev, dry wt. data</i>				9.42		
<i>Mean, wet wt. data</i>				3.82		
<i>Stdev, wet wt. data</i>				2.95		
Killifish	Fish; N. Bedford Harbor	PCBs	NOAEL	9.5	liver	Embryo and larval survival
Striped bass	Eggs; Hudson River	PCBs	EL-no effect	3.1	post yolk-sac larv.	Larval mortality
Winter flounder	Adult and eggs; N. Bedford Harbor	PCBs	EL-no effect	1.08	eggs	Growth rate of larvae
English sole	Adult and eggs; Puget Sound	PCBs	NOAEL	0.09	liver	Production of normal larvae
Killifish	Fish; N. Bedford Harbor	PCBs	NOAEL	0.461	liver	Adult female mortality
<i>Mean, dry wt. data</i>				3.68		
<i>Stdev, dry wt. data</i>				5.05		
<i>Mean, wet wt. data</i>				1.60		
<i>Stdev, wet wt. data</i>				2.13		

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Table 17: Toxicity Endpoints for birds

from Table 4-9 of USEPA Hudson River ERA

Toxicity Endpoints for Laboratory Birds: Effective Concentrations of PCBs and Aroclors

Species	PCB	Exposure duration	Effect Level	Effective Dose (mg/kg)	Effective Food Conc. (mg/kg)	Effect Endpoint
Mallard	Aroclor 1254	5 d	LD ₅₀	853	8122	Mortality
Japanese quail	Aroclor 1254	5 d	LD ₅₀	759	6737	Mortality
Bobwhite quail	Aroclor 1254	5 d	LD ₅₀	141	1516	Mortality
			Mean LD ₅₀	584.33	5458.33	
			Stdev LD ₅₀	388.80	3483.68	
Brown-headed cowbird	Aroclor 1254	7 d	EL-effect	333	1500	Mortality
Red-winged blackbird	Aroclor 1254	6 d	EL-effect	321	1500	Mortality
European starling	Aroclor 1254	4 d	EL-effect	NA	1500	Mortality
Common grackle	Aroclor 1254	8 d	EL-effect	NA	1500	Mortality
			Mean effect level for mortality	327.00	1500.00	
			Mean effect level for mortality	8.49	0.00	
Japanese quail	Aroclor 1260	7 d	LOAEL	100	888	Weight loss
Mallard	Aroclor 1242	12 wk	EL-effect	16	150	wt. loss, hens; eggshell thinning
			Mean growth effect	58.00	519.00	
			Stdev growth effect	59.40	521.84	
Domestic chicken	Aroclor 1254	6 wk	LOAEL	3.5	50	hatching success
Ring-necked pheasant	Aroclor 1254	17 wk	LOAEL	2.9	50	egg production
Ring-necked pheasant	Aroclor 1254	NA	LOAEL	2.9	50	female fertility
Domestic chicken	Aroclor 1242	9 wk	LOAEL	1.4	20	egg prod., hatching success, chick growth
Domestic chicken	Aroclor 1248	9 wk	LOAEL	1.4	20	egg prod., hatching success, chick growth
Domestic chicken	Aroclor 1254	9 wk	LOAEL	1.4	20	egg prod., hatching success, chick growth
Domestic chicken	Aroclor 1242	9 wk	LOAEL	1.4	20	hatching success
Domestic chicken	Aroclor 1254	9 wk	LOAEL	1.4	20	hatching success
Domestic chicken	Aroclor 1248	9 wk	LOAEL	1.4	20	hatching success
Ringed turtle dove	Aroclor 1254	3 mo	EL-effect	1.1	10	hatching success
Ringed turtle dove	Aroclor 1254	NA	LOAEL	1.1	10	hatching success
Domestic chicken	Aroclor 1242	6 wk	LOAEL	0.7	10	hatching success
Domestic chicken	Aroclor 1242	8 wk	LOAEL	0.7	10	hatching success
Domestic chicken	Aroclor 1248	8 wk	LOAEL	0.7	10	hatching success
Domestic chicken	Aroclor 1248	8 wk	LOAEL	0.7	10	hatching success
Domestic chicken	Aroclor 1254	NA	LOAEL	0.3	5	fertility and egg production
			Mean reprod. effects	1.44	20.94	
			Stdev reprod. effects	0.90	15.30	
Mallard	Aroclor 1242	12 wk	EL-no effect	16	150	Reprod & hatching success, surv/growth chick
Japanese quail	Aroclor 1254	14 wk	EL-no effect	5.6	50	mortality and growth of adults
Mallard	Aroclor 1254	1 mo	EL-no effect	2.6	25	reprod. success
Japanese quail	Aroclor 1248	NA	NOAEL	2.3	20	hatching success
Domestic chicken	Aroclor 1016	8 wk	NOAEL	1.4	20	egg production
Domestic chicken	Aroclor 1254	8 wk	NOAEL	1.4	20	egg production
Domestic chicken	Aroclor 1221	9 wk	EL-no effect	1.4	20	hatching success
Domestic chicken	Aroclor 1232	9 wk	EL-no effect	1.4	20	hatching success
Domestic chicken	Aroclor 1268	9 wk	EL-no effect	1.4	20	hatching success
Domestic chicken	Aroclor 1242	9 wk	EL-no effect	1.4	20	hatching success
Ring-necked pheasant	Aroclor 1254	17 wk	NOAEL	0.7	12.5	egg production
Screech owl	Aroclor 1248	> 8 wk	EL-no effect	0.4	3	egg production, hatch & fledging success
Domestic chicken	Aroclor 1242	6 wk	NOAEL	0.3	5	hatching success
Domestic chicken	Aroclor 1242	8 wk	NOAEL	0.3	5	hatching success
Domestic chicken	Aroclor 1248	8 wk	NOAEL	0.3	5	hatching success
Domestic chicken	Aroclor 1242	9 wk	NOAEL	0.1	2	egg prod., hatching success, chick growth
Domestic chicken	Aroclor 1248	9 wk	NOAEL	0.1	2	egg prod., hatching success, chick growth
Domestic chicken	Aroclor 1254	9 wk	NOAEL	0.1	2	egg prod., hatching success, chick growth
Domestic chicken	Aroclor 1242	9 wk	NOAEL	0.1	2	hatching success
Domestic chicken	Aroclor 1248	9 wk	NOAEL	0.1	2	hatching success
Domestic chicken	Aroclor 1254	9 wk	NOAEL	0.1	2	hatching success
Domestic chicken	Aroclor 1248	9 wk	NOAEL	0.1	1	hatching success
			Mean reprod. effects	1.71	18.57	
			Stdev reprod. effects	3.44	31.70	

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Figure 18: Dicks Creek Sediment Dry Weights

<i>Treatment</i>	<i>Rep</i>	<i>Pan Wt.</i>	<i>Pan + Wet Sed Wt.</i>	<i>Wet Sediment Wt.</i>	<i>Mean Wet Wt.</i>	<i>Dry Sed + Pan Wt.</i>	<i>Sediment Wt.</i>	<i>Mean Dry Sed Wt.</i>	<i>Wet/Dry Ratio</i>
<i>Trout</i>	1	1.01188	9.66682	8.65494	8.33115	3.50981	2.49793	2.69760	3.09
	2	1.01222	9.24002	8.22780		4.08063	3.06841		
	3	1.01217	9.12287	8.11070		3.53863	2.52646		
<i>North Branch</i>	1	1.01207	20.14408	19.13201	20.50218	18.43286	17.42079	17.86909	1.15
	2	1.01599	27.77048	26.75449		24.12977	23.11378		
	3	1.01125	16.63128	15.62003		14.08396	13.07271		
<i>Ceasar's Creek</i>	1	1.00630	22.72227	21.71597	22.21156	17.19180	16.18550	16.79337	1.32
	2	1.00934	18.90054	17.89120		15.00713	13.99779		
	3	1.01084	28.03835	27.02751		21.20766	20.19682		
<i>Beaver Dam</i>	1	1.01856	12.49603	11.47747	13.01753	10.51298	9.49442	10.77677	1.21
	2	1.01001	11.23372	10.22371		9.49288	8.48287		
	3	1.00866	18.36006	17.35140		15.36168	14.35302		
<i>Amanda</i>	1	1.04663	23.12463	22.07800	24.06432	19.17274	18.12611	19.70707	1.22
	2	1.05206	23.96518	22.91312		19.93327	18.88121		
	3	1.03916	28.24099	27.20183		23.15305	22.11389		

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Table 19: Dicks Creek Lab Test, July 2000
Exposure Duration = 10d, 11-21 July 2000

Rep	LITTLE SUGAR CREEK		AMANDA		USGS		WATER CONTROL		SEDIMENT CONTROL	
	<i>H. azteca</i>	<i>C. tentans</i>	<i>H. azteca</i>	<i>C. tentans</i>	<i>H. azteca</i>	<i>C. tentans</i>	<i>H. azteca</i>	<i>C. tentans</i>	<i>H. azteca</i>	<i>C. tentans</i>
1	10	10	8	7	9	9	12	11	10	9
2	9	10	10	9	10	10	8	10	10	9
3	9	10	10	9	10	10	10	9	10	9
4	8	10	8	10	8	9	9	9	8	10
Mean	9	10	9	8.75	9.25	9.5	9.75	9.75	9.5	9.25
SD	0.82	0.00	1.15	1.26	0.96	0.58	1.71	0.96	1.00	0.50
% Mean	90	100	90	87.5	92.5	95	97.5	97.5	95	92.5
St. De	8.16	0.00	11.55	12.58	9.57	5.77	17.08	9.57	10.00	5.00

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Table 20: Dicks Creek Laboratory Aug/Sept 2000 (Test 2)

8/25/00 - 9/4/00

Dm - 48hr

Pp & *Lv* - 96hr

Ha & *Ct* - 10d

Treatment	Rep	<i>D. magna</i>	<i>C. tentans</i>	<i>H. azteca</i>	<i>P. promelas</i>
Lab Sed Ctl	1	8.00	10.00	10.00	5.00
	2	10.00	10.00	9.00	4.00
	3	9.00	8.00	9.00	7.00
	4	9.00	10.00	10.00	5.00
	% Mean	90.00	95.00	95.00	52.50
	% St. Dev	8.16	10.00	5.77	12.58
Lab Water Ctl	1	10.00	10.00	7.00	5.00
	2	10.00	9.00	10.00	4.00
	3	10.00	7.00	6.00	6.00
	4	9.00	10.00	9.00	6.00
	% Mean	97.50	90.00	80.00	52.50
	% St. Dev	5.00	14.14	18.26	9.57
LSC	1	9.00	10.00	8.00	4.00
	2	9.00	10.00	9.00	5.00
	3	9.00	10.00	7.00	4.00
	4	10.00	10.00	9.00	3.00
	% Mean	92.50	100.00	82.50	40.00
	% St. Dev	5.00	0.00	9.57	8.16
LBF	1	10.00	8.00	9.00	4.00
	2	10.00	9.00	7.00	6.00
	3	10.00	8.00	6.00	5.00
	4	9.00	8.00	9.00	3.00
	% Mean	97.50	82.50	77.50	45.00
	% St. Dev	5.00	5.00	15.00	12.91
Amanda	1	10.00	6.00	10.00	4.00
	2	9.00	8.00	10.00	2.00
	3	7.00	7.00	8.00	4.00
	4	10.00	7.00	10.00	3.00
	% Mean	90.00	70.00	95.00	32.50
	% St. Dev	14.14	8.16	10.00	9.57
USGS	1	6.00	8.00	8.00	3.00
	2	2.00	8.00	10.00	6.00
	3	9.00	7.00	9.00	4.00
	4	6.00	10.00	6.00	4.00
	% Mean	57.50	82.50	82.50	42.50
	% St. Dev	28.72	12.58	17.08	12.58

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**Table 21: Test Organism Survival at the Reference Site (Little Sugar Creek) vs. The Dicks Creek Test Sites ANOVAs (statistical significance)
Dicks Creek June 2000**

x = sample survival is significantly different from control survival

Hyalella azteca

	LSC	Amanda	USGS
WC			
AS		x	x
SS			x

Daphnia magna

	LSC	Amanda	USGS
WC			
AS			
SS		x	x

Chironomus tentans

	LSC	Amanda	USGS
WC			
AS			x
SS			x
PW			x

Pimephales promelas

	LSC	Amanda	USGS
WC			
AS			x

AK5 041684

Table 22 : Recommended test conditions for conducting a 10-d sediment toxicity test with *Hyalella azteca*

Parameter	Conditions
Test type	Whole-sediment toxicity test with renewal of overlying water
Temperature	23 ± 1°C
Light quality	Wide-spectrum fluorescent lights
Illuminance	About 100 to 1000 lux
Photoperiod	16 light: 8 dark
Test chamber	300 ml high-form lipless beaker
Sediment volume	100 ml
Overlying water volume	175 ml
Renewal of overlying water	2 volume additions/24-h; continuous or intermittent (e.g., one volume addition every 12h)
Age of organism	7-14d old at the start of the test (1- to 2- range in age)
Number of organisms/chamber	10
Number of replicate chambers/treatment	Depends on the objective of the test. Eight replicates are recommended for routine testing.
Feeding	YCT food, fed 1.0 mL daily (1800mg/L stock) to each test chamber.
Aeration	None, unless D.O. in overlying water drops below 2.5 mg/L
Overlying water	Culture water, well water, surface water, site water or reconstituted Water.
Test chamber cleaning	If screens clog during test, gently brush from outside of the screen.
Overlying water quality	Hardness, alkalinity, conductivity and total ammonia at the beginning and end of a test. Temperature and dissolved oxygen daily.
Test duration	10d
Endpoints	Survival and growth.
Test acceptability	Minimum mean control survival must be 70%, with a minimum mean weight/surviving control organism of 0.48 mg AFDW. Performance based criteria specifications are outlined in table 12.3.

Table 23: General activity schedule for conducting a 10-d sediment toxicity test with *Hyalella azteca*

Day	Activity
-7	Separate known-age amphipods from the cultures and place in holding chambers. Begin preparing food for the test. There should be a 1- to 2-d range in age of amphipods used to start the test.
-6 to 12	Feed and observe isolated amphipods, monitor water quality ⁹ (e.g., temperature and dissolved oxygen).
-1	Feed and observe isolated amphipods, monitor water quality. Add sediment into each test chamber, place chambers into exposure system, and start renewing overlying water.
0	Measure total water quality (pH, temperature, dissolved oxygen, hardness, alkalinity, conductivity, ammonia). Transfer 10 7- to 14-day-old amphipods into each test chamber. Release organisms under the surface of the Water. Add 1.0 mL of YCT into each test chamber. Archive 20 organisms for length determination. Observe behavior of test organisms.
1 to 8	Add 1.0 of YCT food to each test chamber. Measure temperature and dissolved oxygen. Observe behavior of test organisms.
9	Measure total water quality.
10	Measure temperature and dissolved oxygen. End the test by collecting the amphipods with a sieve. Count survivors and prepare organisms for weight or length measurements.

Table 24 : Recommended test conditions for conducting a 10-d sediment toxicity test with *chironimus tentans*

Parameter	Conditions
Test type	Whole-sediment toxicity test with renewal of overlying water
Temperature	23 ± 1°C
Light quality	Wide-spectrum fluorescent lights
Illuminance	About 100 to 1000 lux
Photoperiod	16 light: 8 dark
Test chamber	300 ml high-form lipless beaker
Sediment volume	100 ml
Overlying water volume	175 ml
Renewal of overlying water	2 volume additions/24h; continuous or intermittent (e.g., one volume addition every/12-h)
Age of organism	Second to third instar larvae (about 10d old larvae; all organisms must be third instar or younger with at least 50% of the organisms at third instar.
Number of organisms/chamber	10
Number of replicate chambers/treatment	Depends on objective of the test. Eight replicates are recommended for routine testing.
Feeding	1.5 ml Tetrafin [®] goldfish food to each test chamber daily.
Aeration	None, unless D.O. in overlying water drops below 2.5 mg/L
Overlying water	Culture water, well water, surface water, site water or reconstituted water.
Test chamber cleaning	If screens clogged during a test, gently brush the outside of the screen.
Overlying water quality	Hardness, alkalinity, conductivity, pH and ammonia at the beginning and end of a test. Temperature and dissolved oxygen daily.
Test duration	10 d
Endpoints	Survival and growth (ash-free dry weight, AFDW).
Test acceptability	Minimum mean control survival must be 70%, with minimum mean weight/surviving control organisms of 0.48 mg AFDW.

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Table 25: General activity schedule for conducting a 10-d sediment toxicity test with *Chironomus tentans*

Day	Activity
-14	Isolated adults for production of egg cases.
-13	Place newly deposited egg cases into hatching dishes.
-12	Prepare a larval rearing chamber with new substrate.
-11	Examine egg cases for hatching success. If egg cases have hatched, transfer first-instar larvae and any remaining unhatched embryos from the crystallizing dishes into the larval rearing chamber. Feed organisms.
-10	Same as Day -11.
-9 to -20	Feed and observe midges. Measure water quality (e.g., temperature and dissolved oxygen).
0	Measure total water quality (temperature, dissolved oxygen, conductivity, ammonia). Remove third instar larvae from the culture chamber substrate. Add 1.5 mL of Tetrafin (4.0g/L) into each test chamber. Transfer 10 larvae into each test chamber. Release organisms under the surface of the water. Archive 20 test organisms for instar determination and weight or length determination. Observe behavior of test organisms.
1 to 8	Add 1.5 mL of food to each test chamber. Measure temperature and dissolved oxygen. Observe behavior of test organisms.
9	Measure total water quality.
10	Measure temperature and dissolved oxygen. End the test by collecting the midges with a sieve. Measure weight Or length of the surviving larvae.

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FIGURES

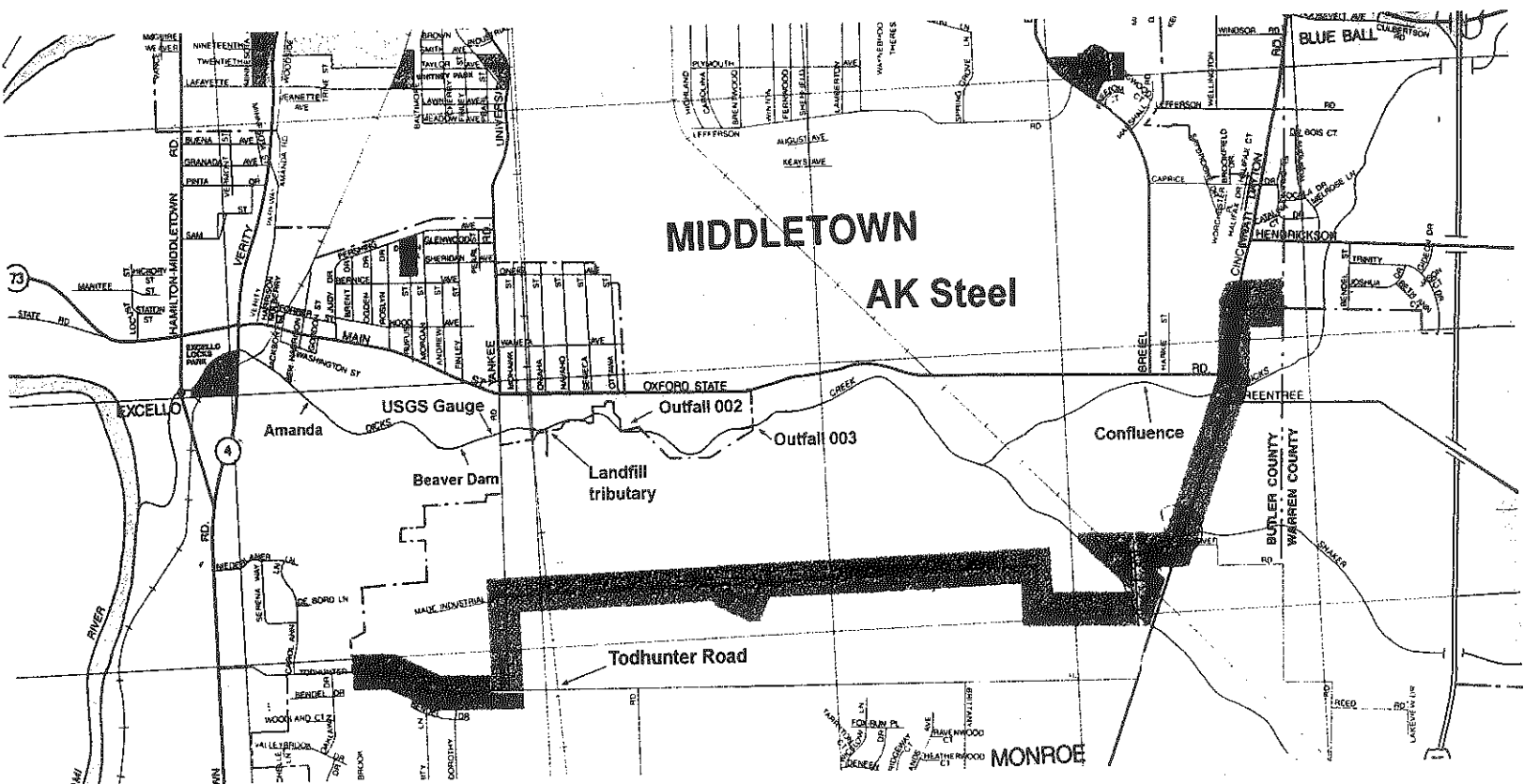
AK5 041689

Fig. 1. Middletown Location

AK5 041690

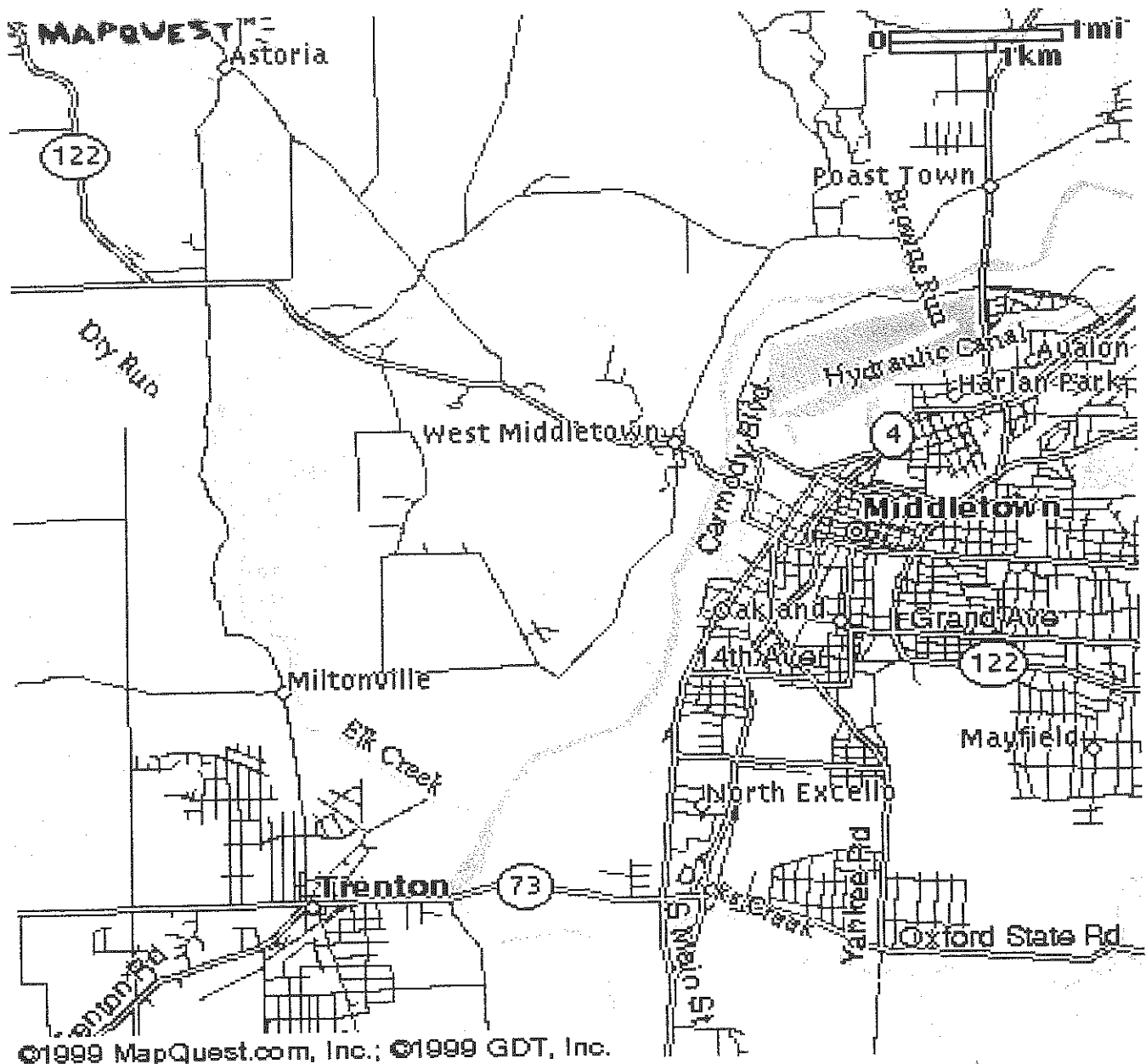


Figure 2. Dicks Creek



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Figure 3. Elk Creek



AK5 041692

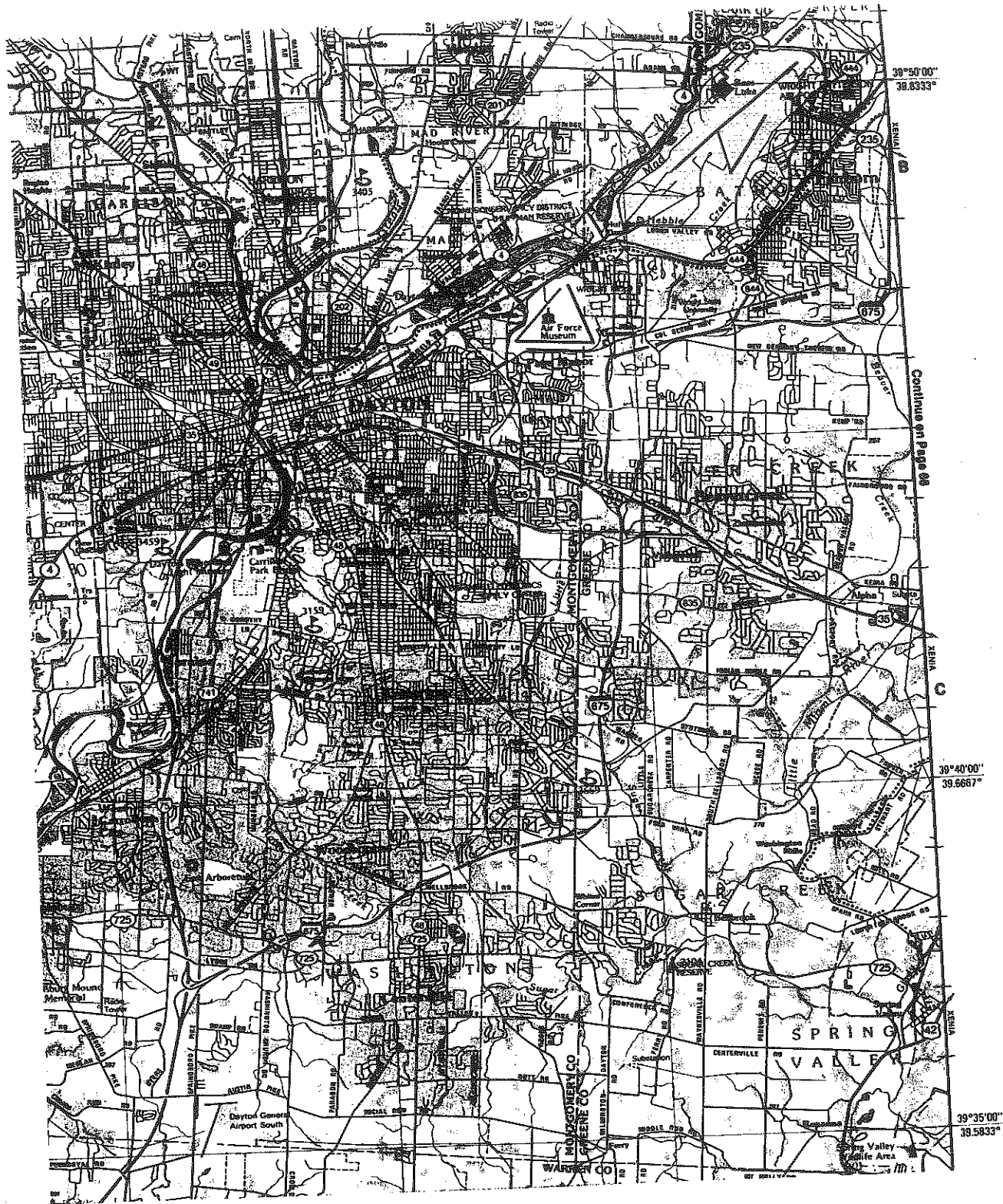


Fig.4. Little Sugar Creek Reference

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Figure 5. Food web

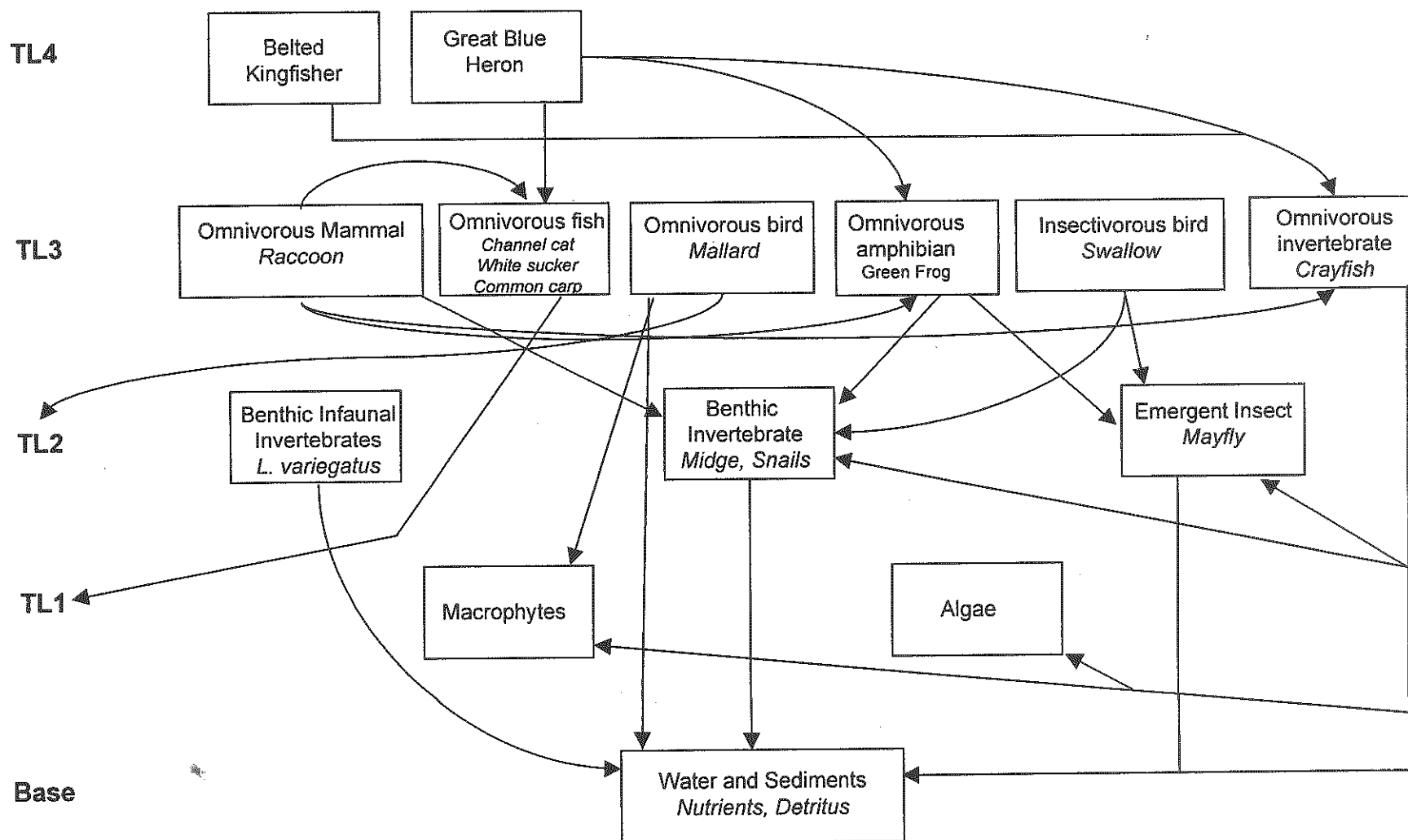


Figure 6: 7d In Situ Survival
Dicks Creek 1998

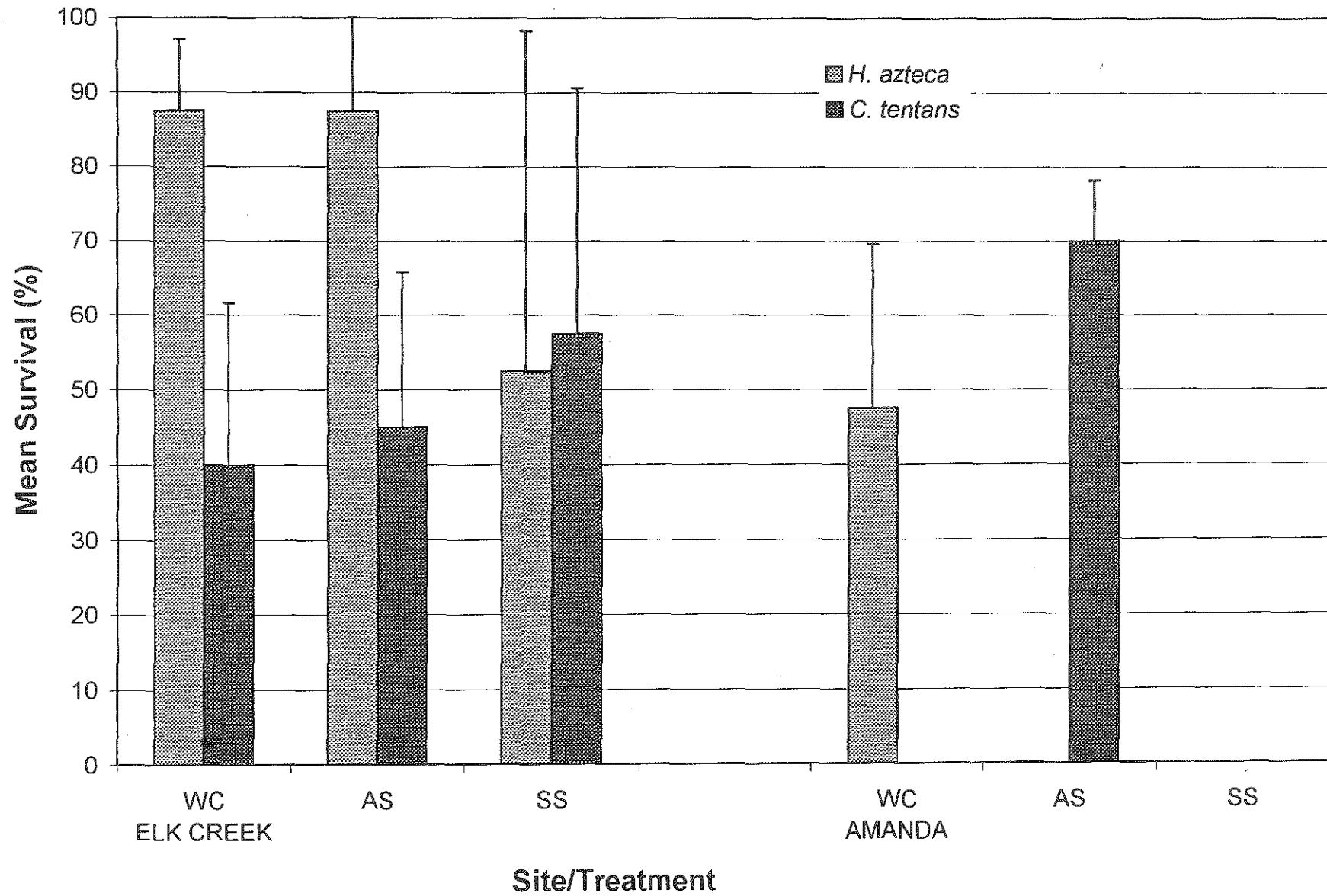
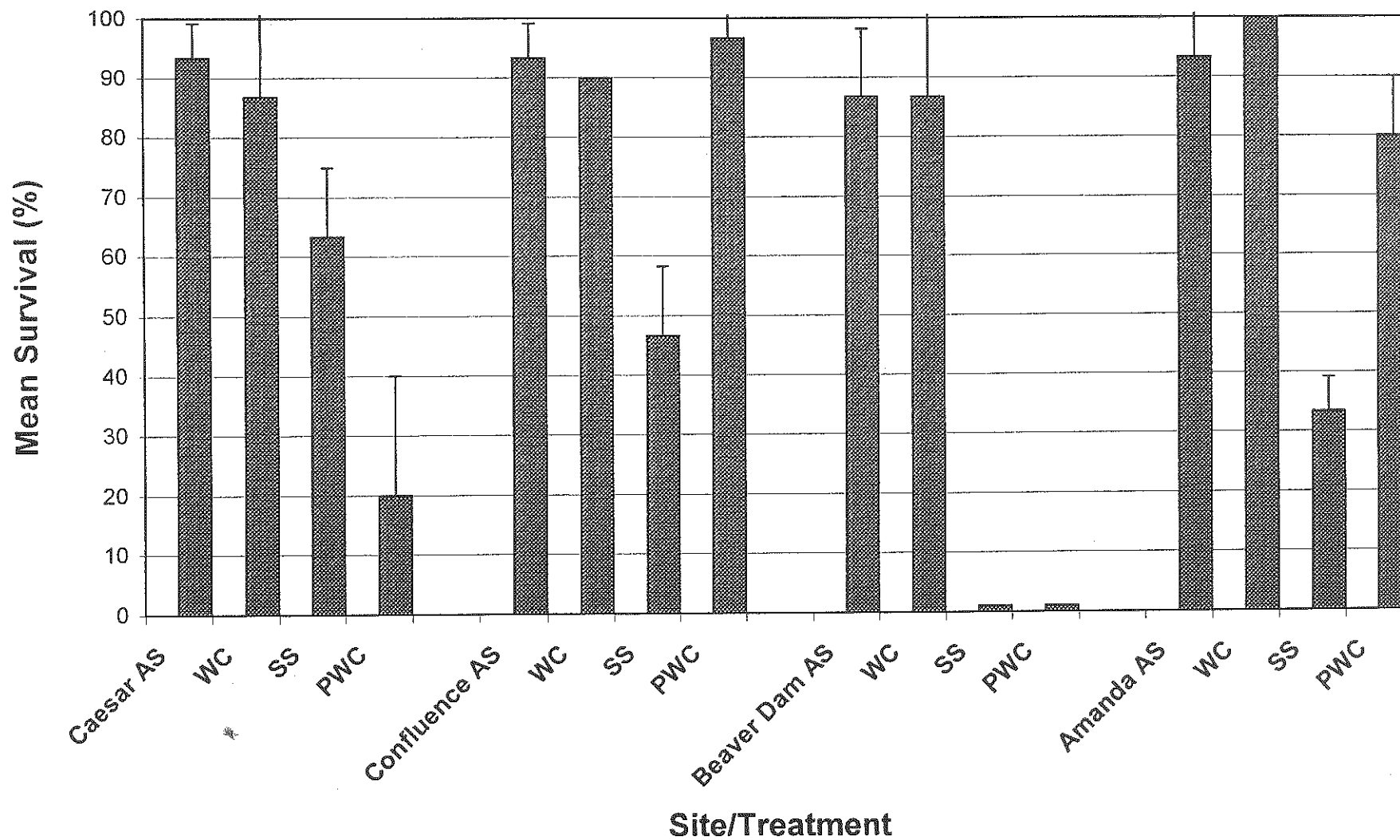


Figure 7: *H. azteca* 4d *In Situ* Survival
Dicks Creek, Sept-Oct 1999



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Figure 8: Total Sediment PCBs
Dicks Creek 1999

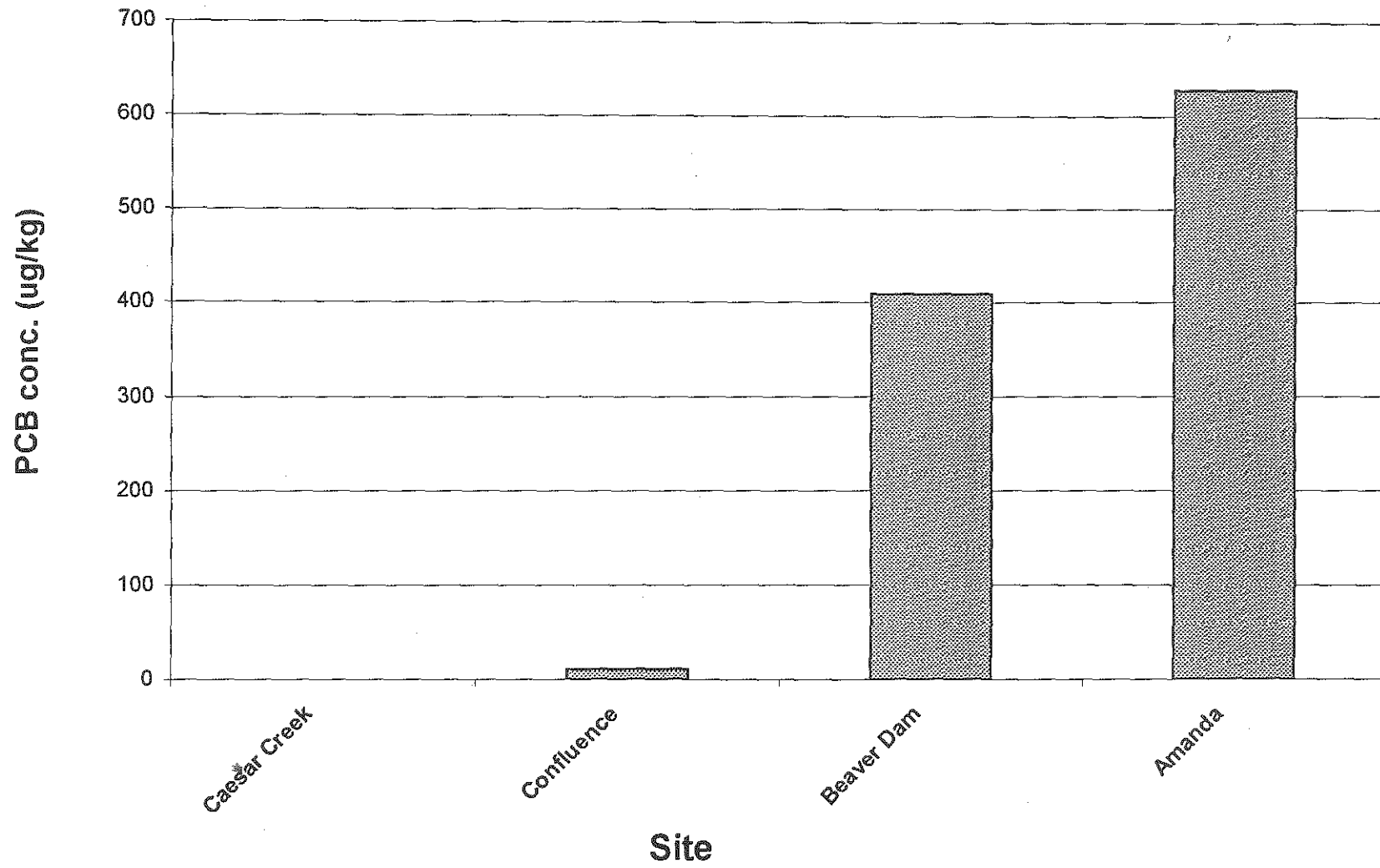


Figure 9: Total PCB Levels in *L. variegatus* Tissues
4d *In Situ* Exposure, Dicks Creek 1999

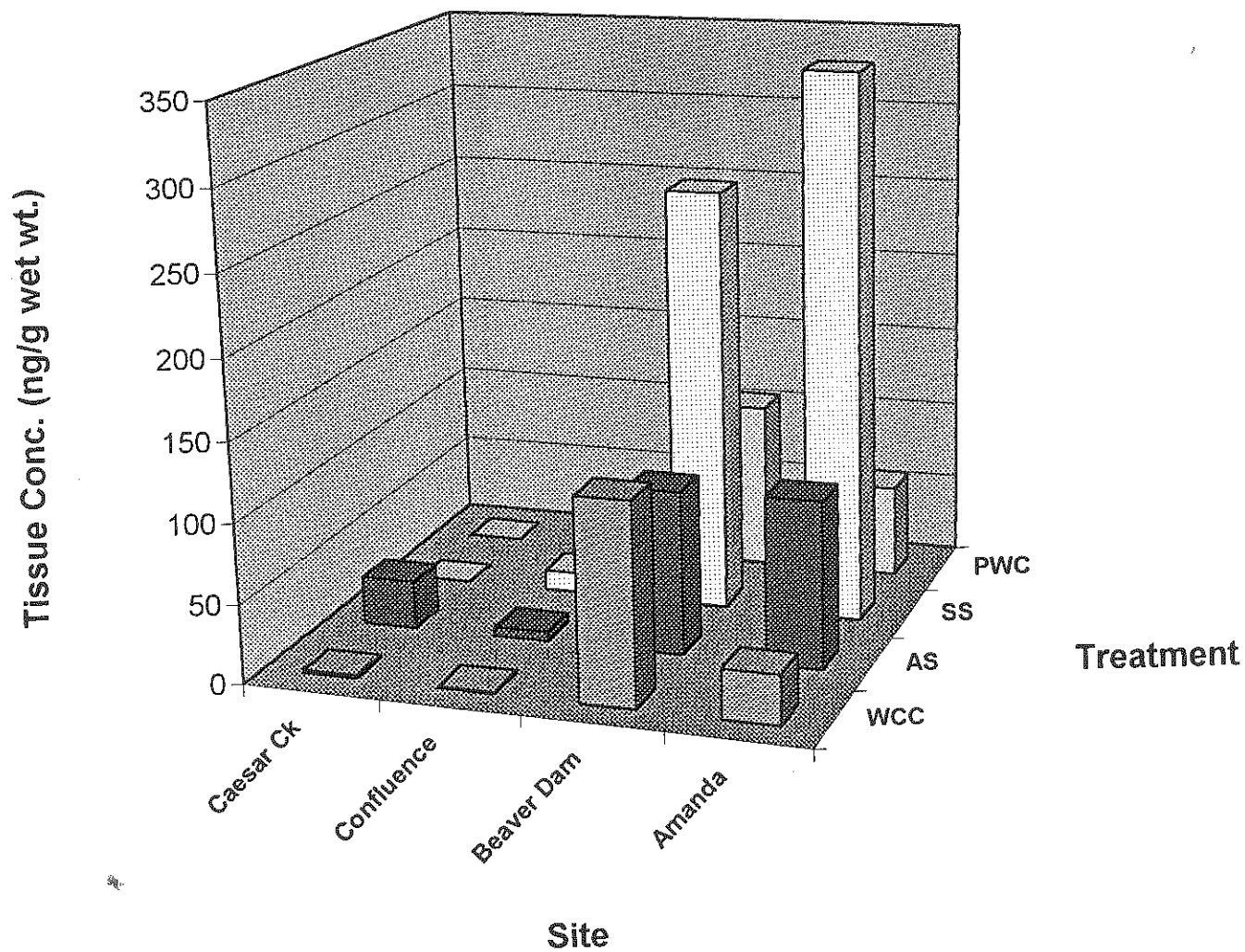


Figure 10: PCB Levels in *L. variegatus* Tissue
by Isomer Region
Surficial Sediment (SS) *In Situ* Exposure, Dicks Creek 1999

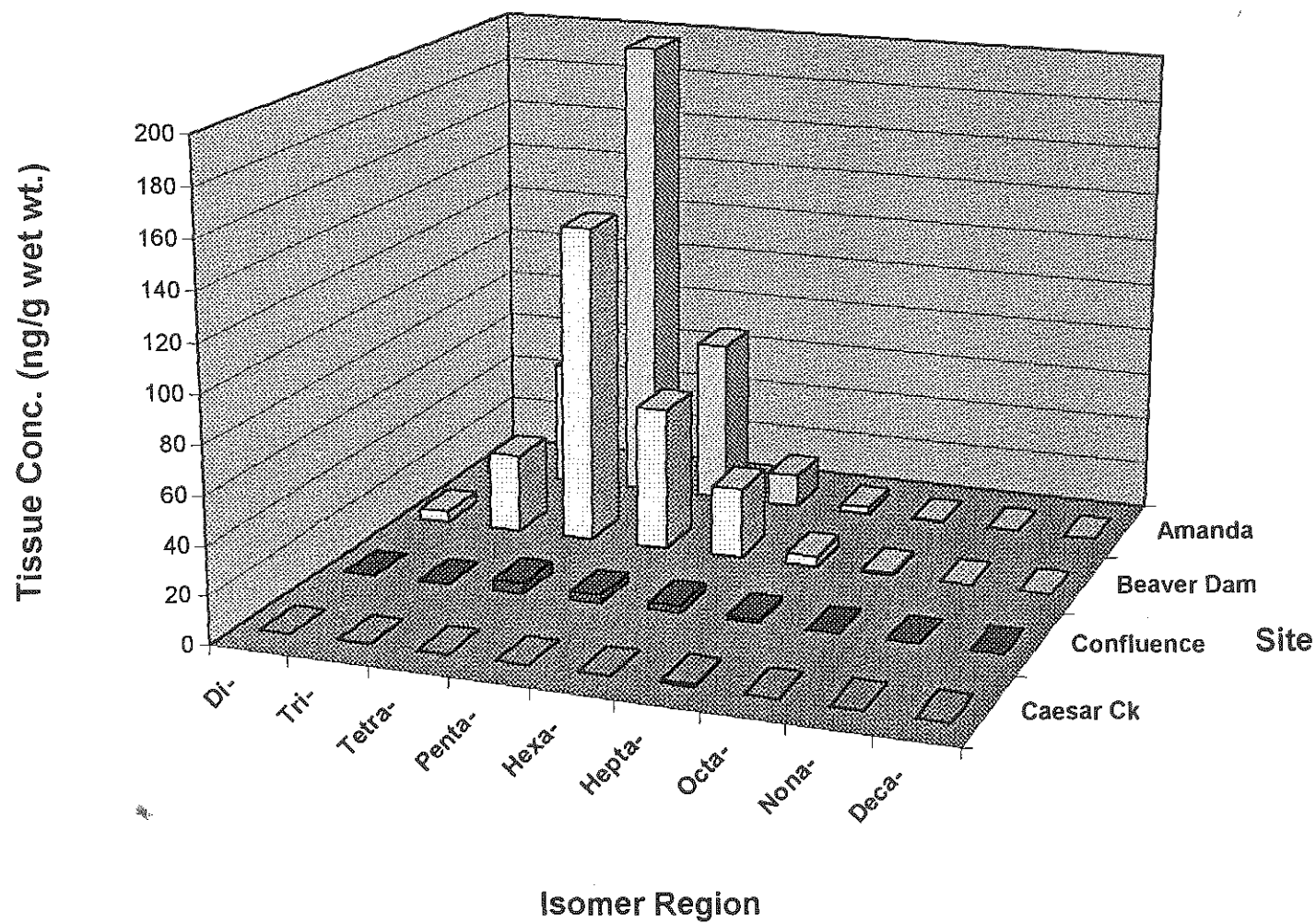


Figure 11: PCB levels in Tissues by Isomer Region -
Against Sediment (AS) *In Situ* Exposure, Dicks Creek, 1998

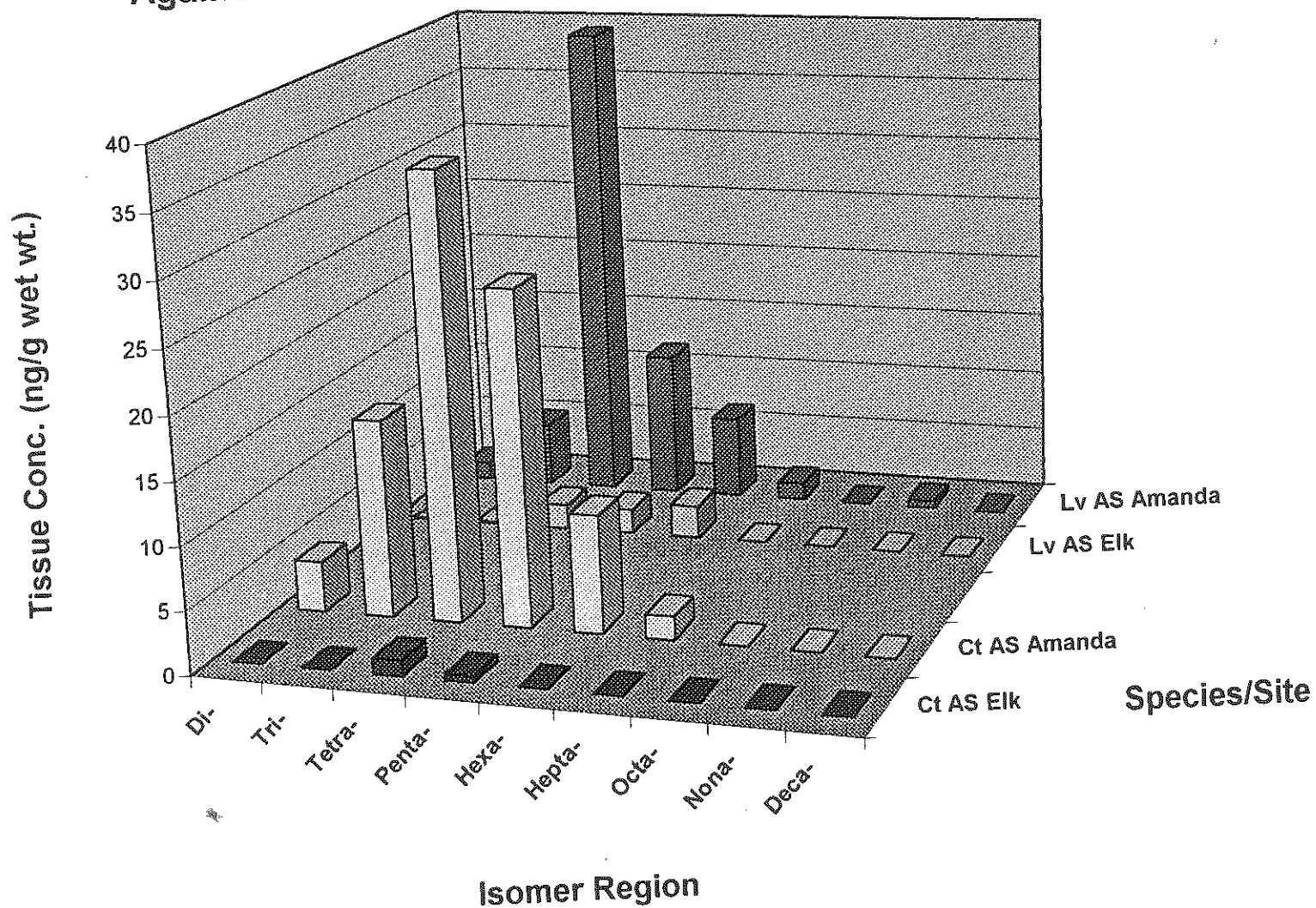
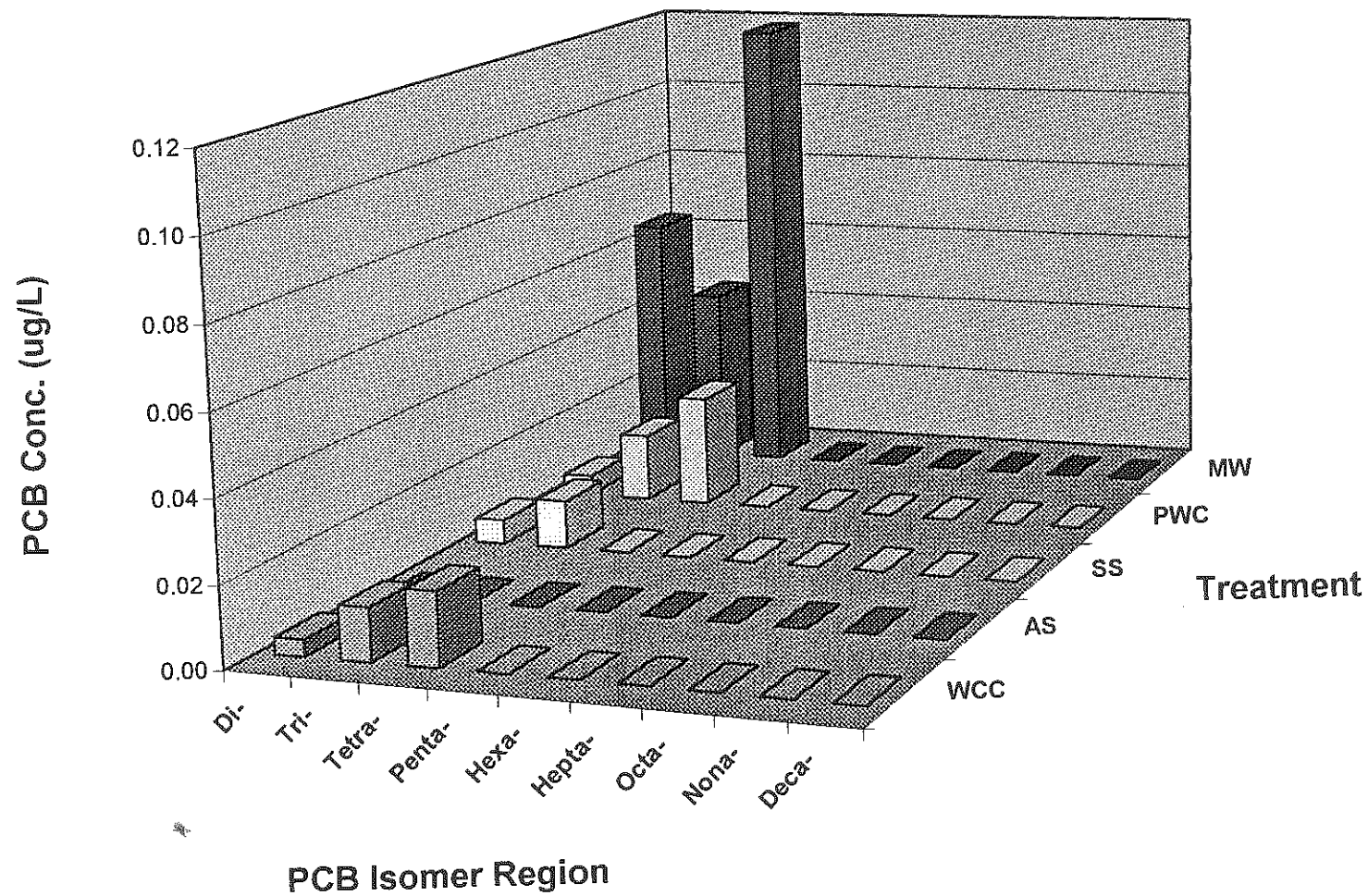
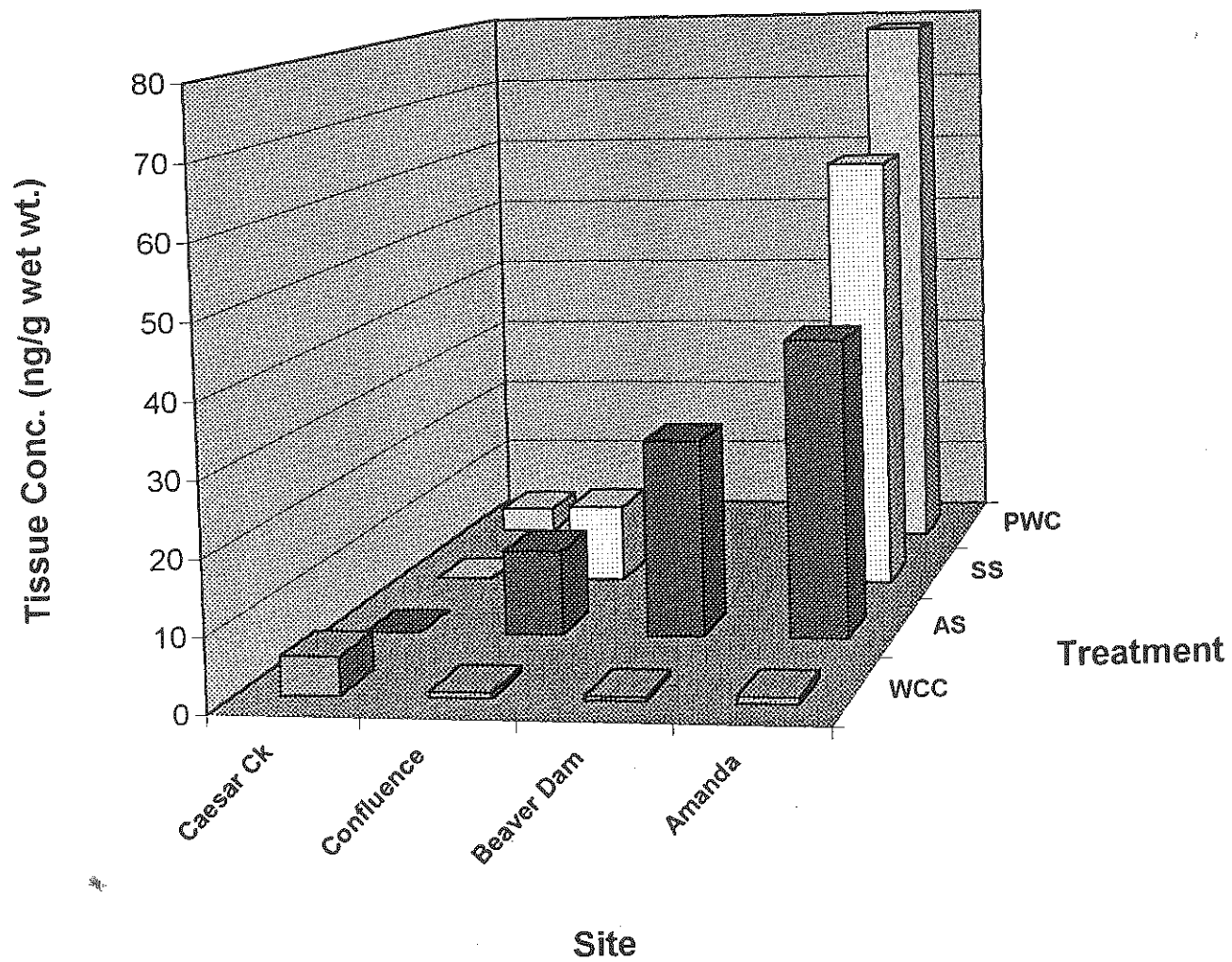


Figure 12: Total Water PCBs by Isomer Region
In Situ Exposure at Amanda, Dicks Creek 1999



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Figure 13: Total PCBs in *H. azteca* Tissue
In Situ Exposure, Dicks Creek 1999



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Figure 14: Total PCB Levels *L. variegatus* Tissue
4-d Laboratory Bioassay, Dicks Creek 1999

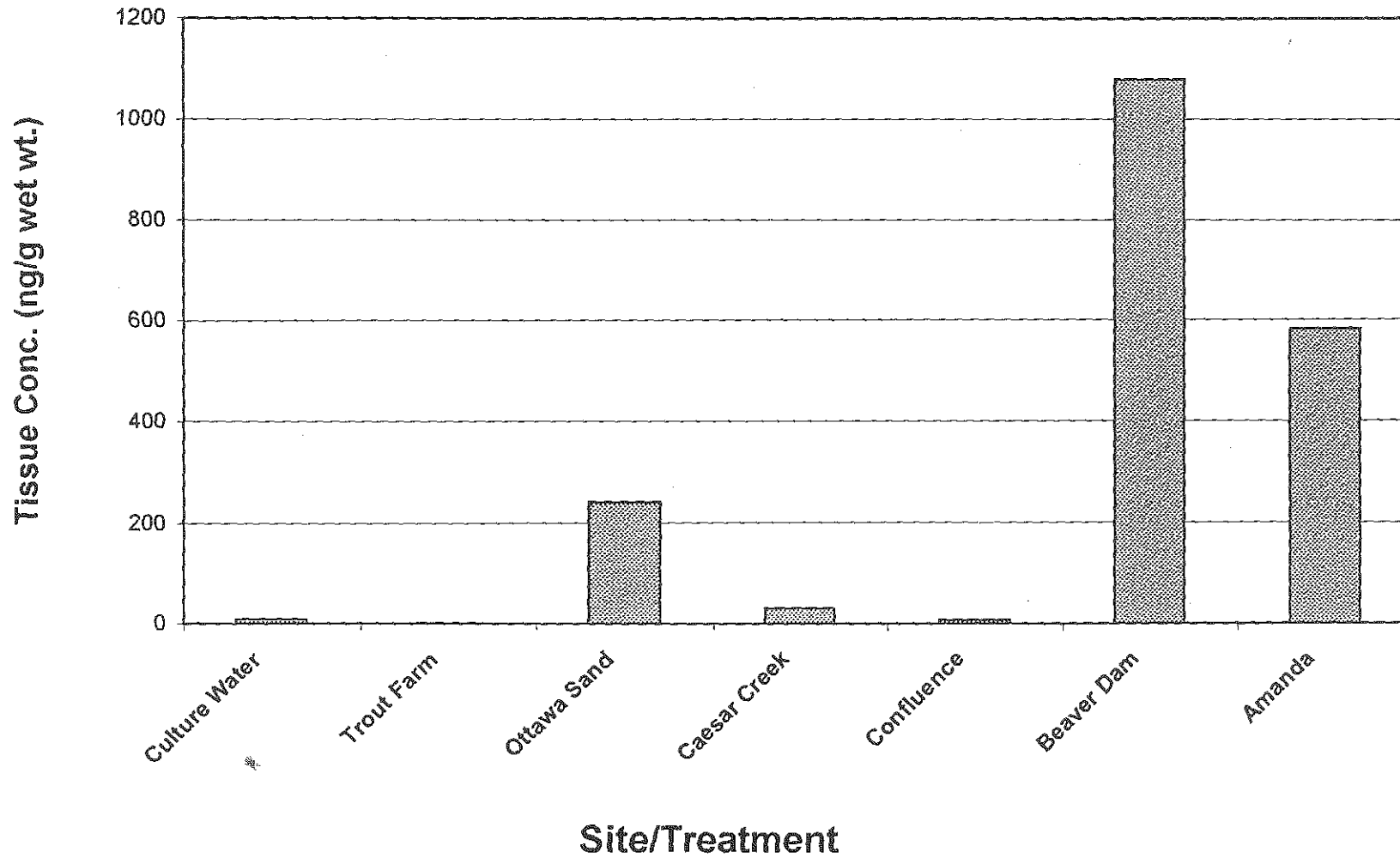


Figure 15: PCB Levels in *L. variegatus* Tissues
by Isomer Region
4-d Laboratory Bioassay, Dicks Creek 1999

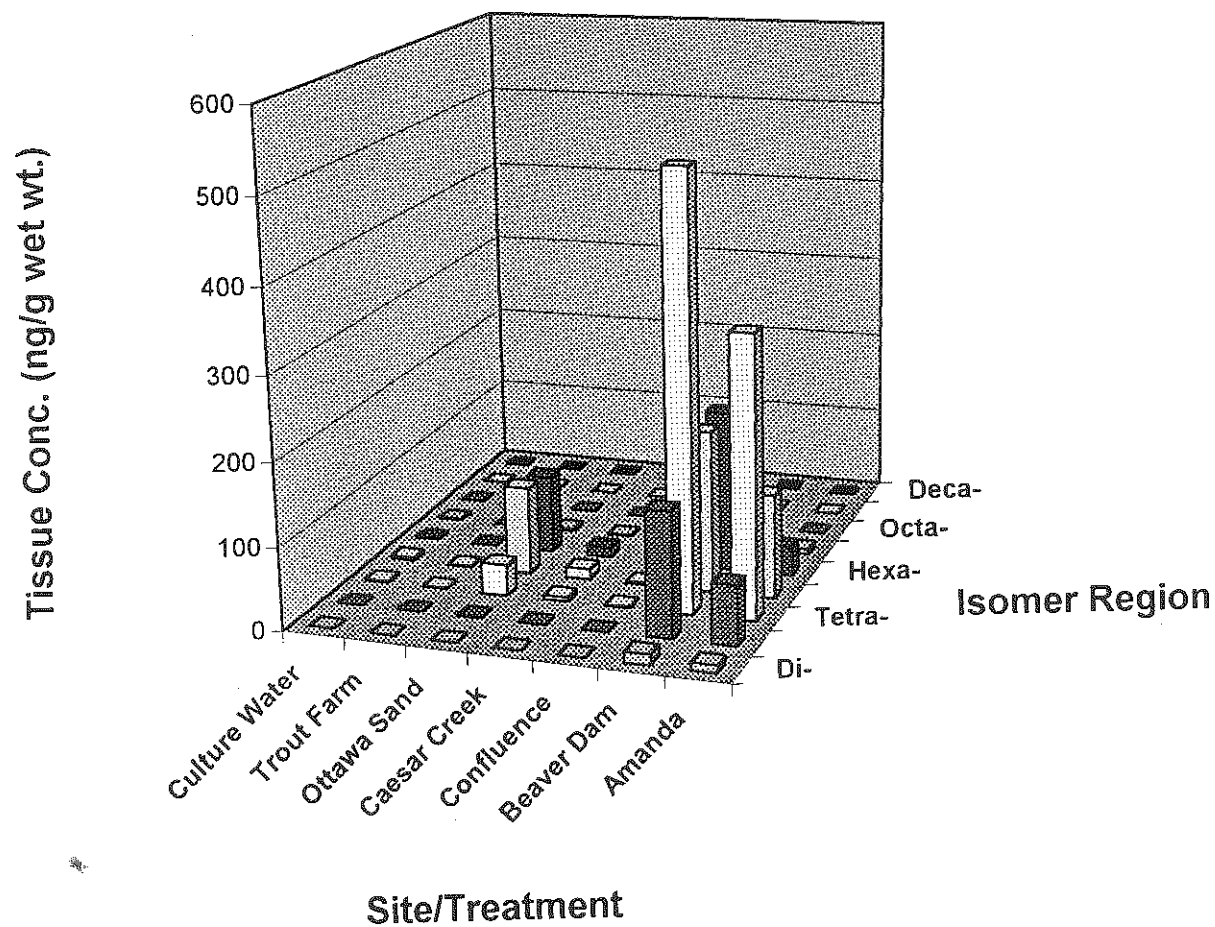


Figure 15: PCB Levels in *L. variegatus* Tissues
by Isomer Region
4-d Laboratory Bioassay, Dicks Creek 1999

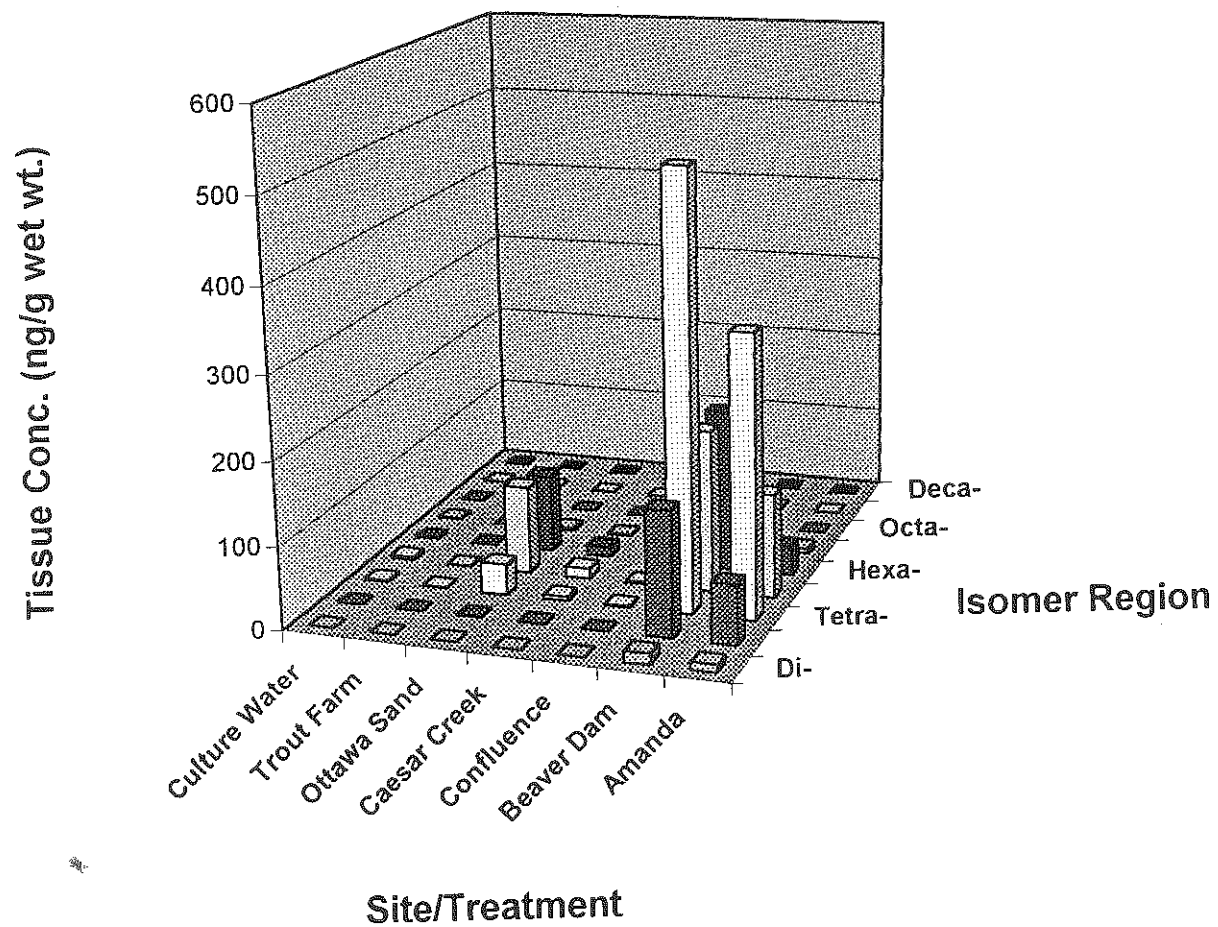
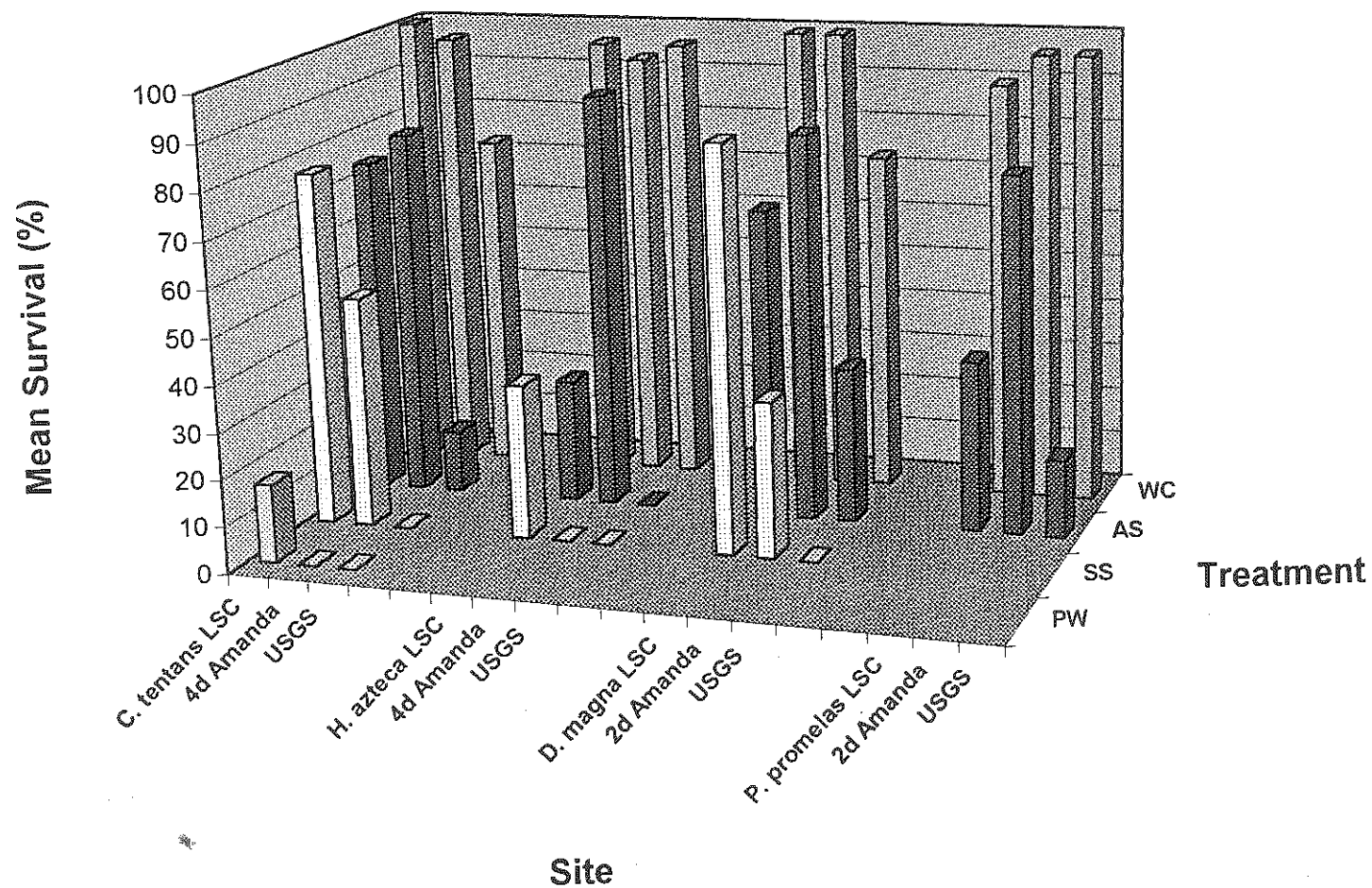


Figure 16: In Situ Survival
August 2000, Dicks Creek



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Figure 17: Total Sediment PCBs
Dicks Creek, August 2000

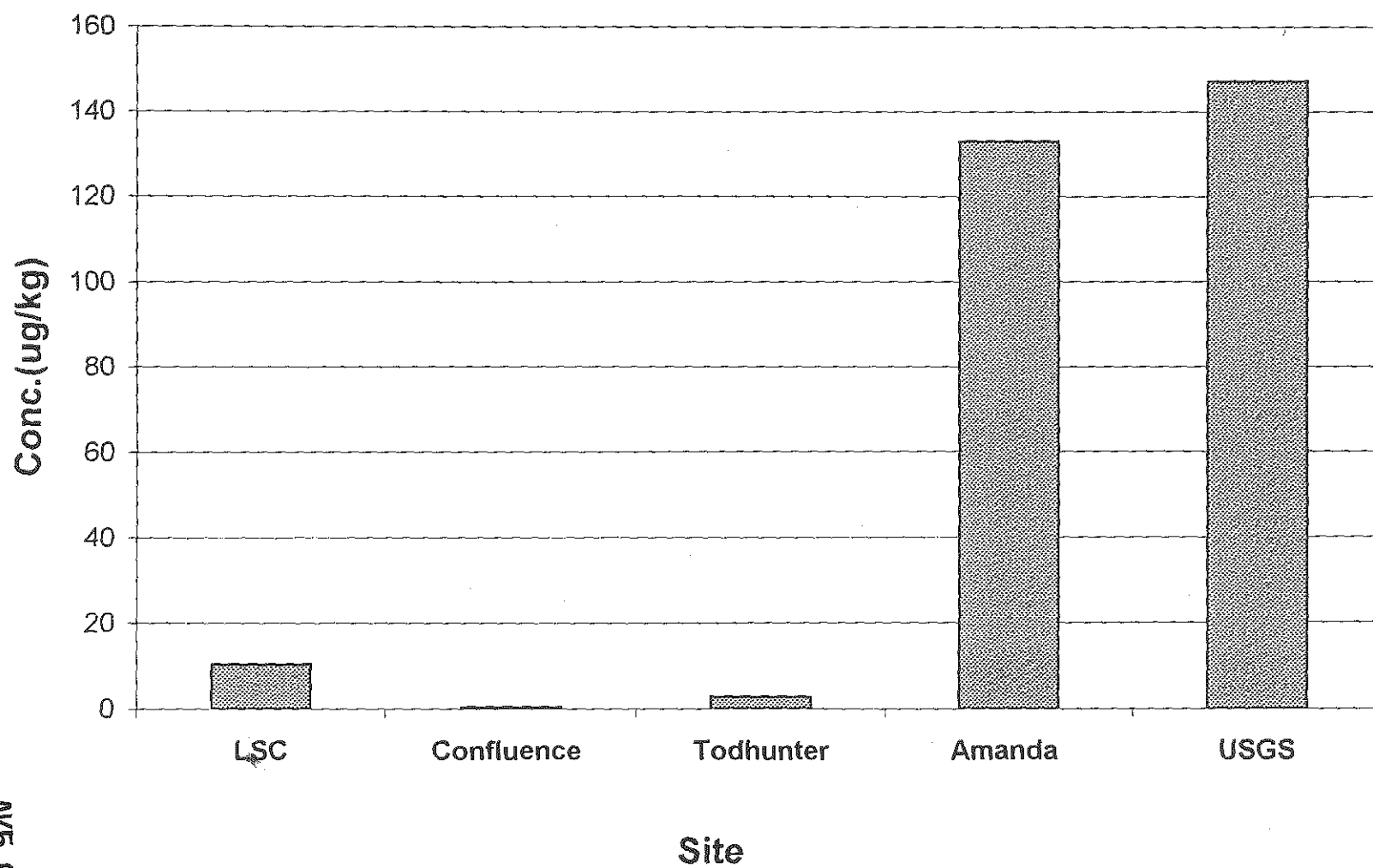
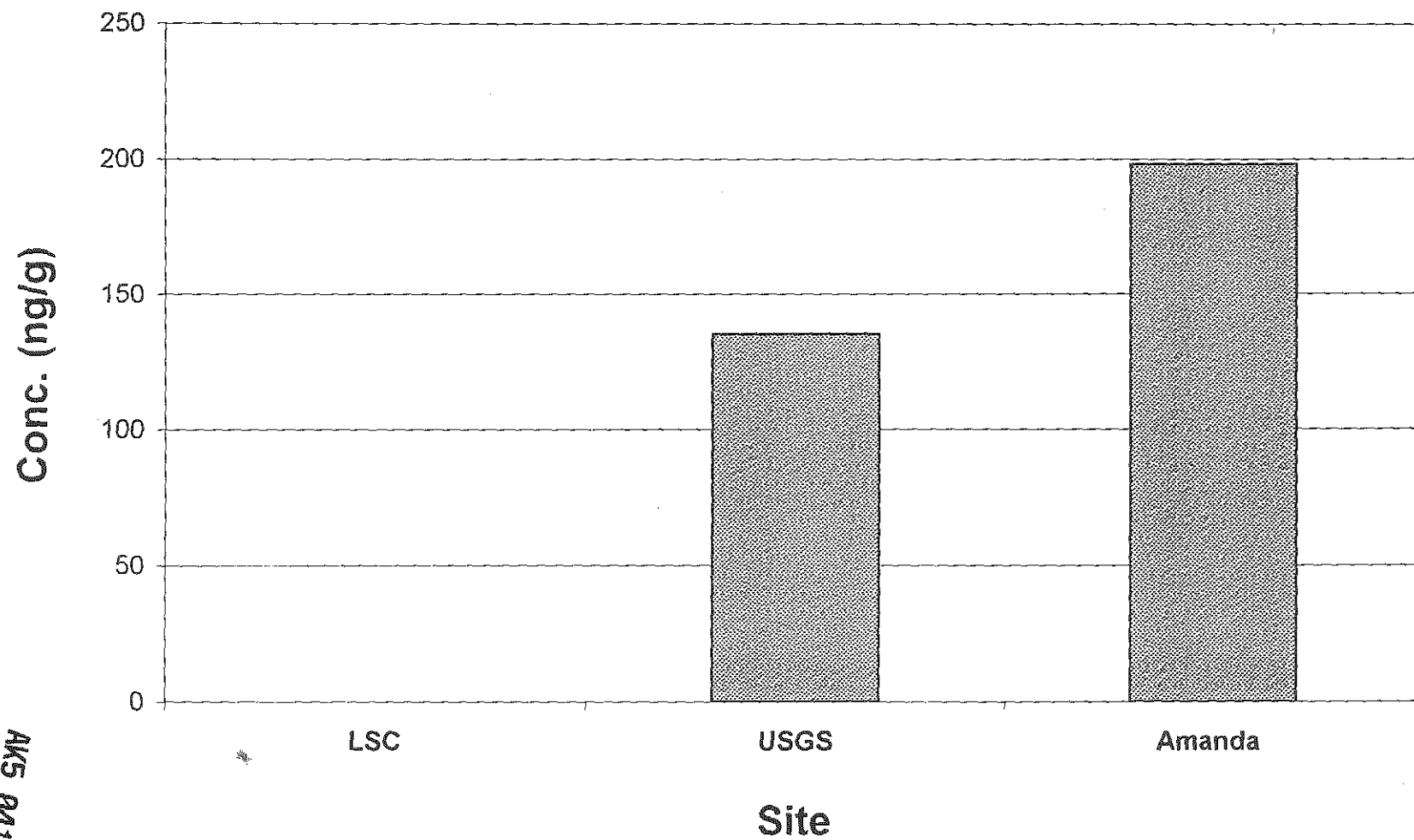
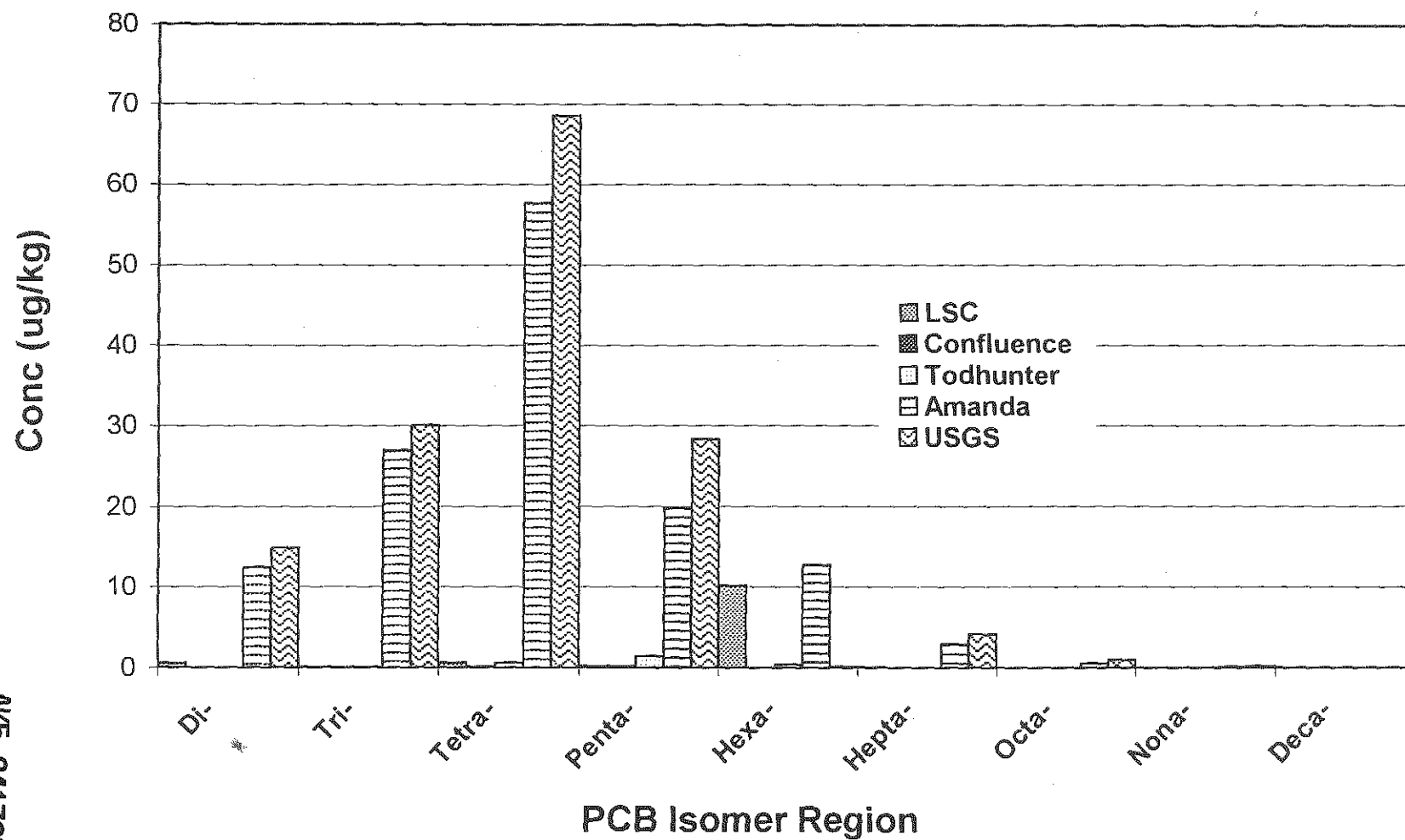


Figure 18: Total Sediments PCBs
Dicks Creek, June 2000



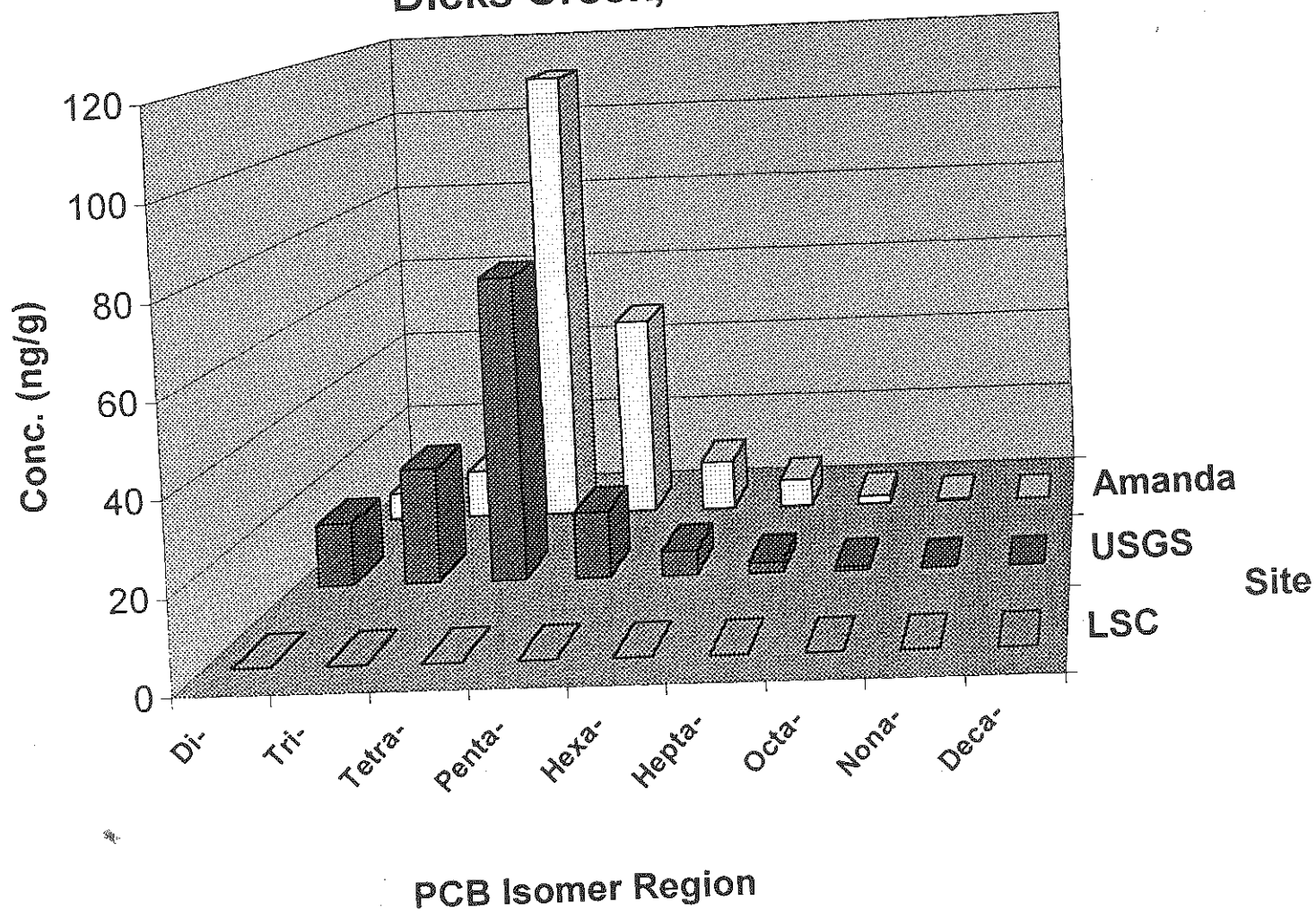
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Figure 19: Sediment PCB Levels by Isomer Region
Dicks Creek, August 2000



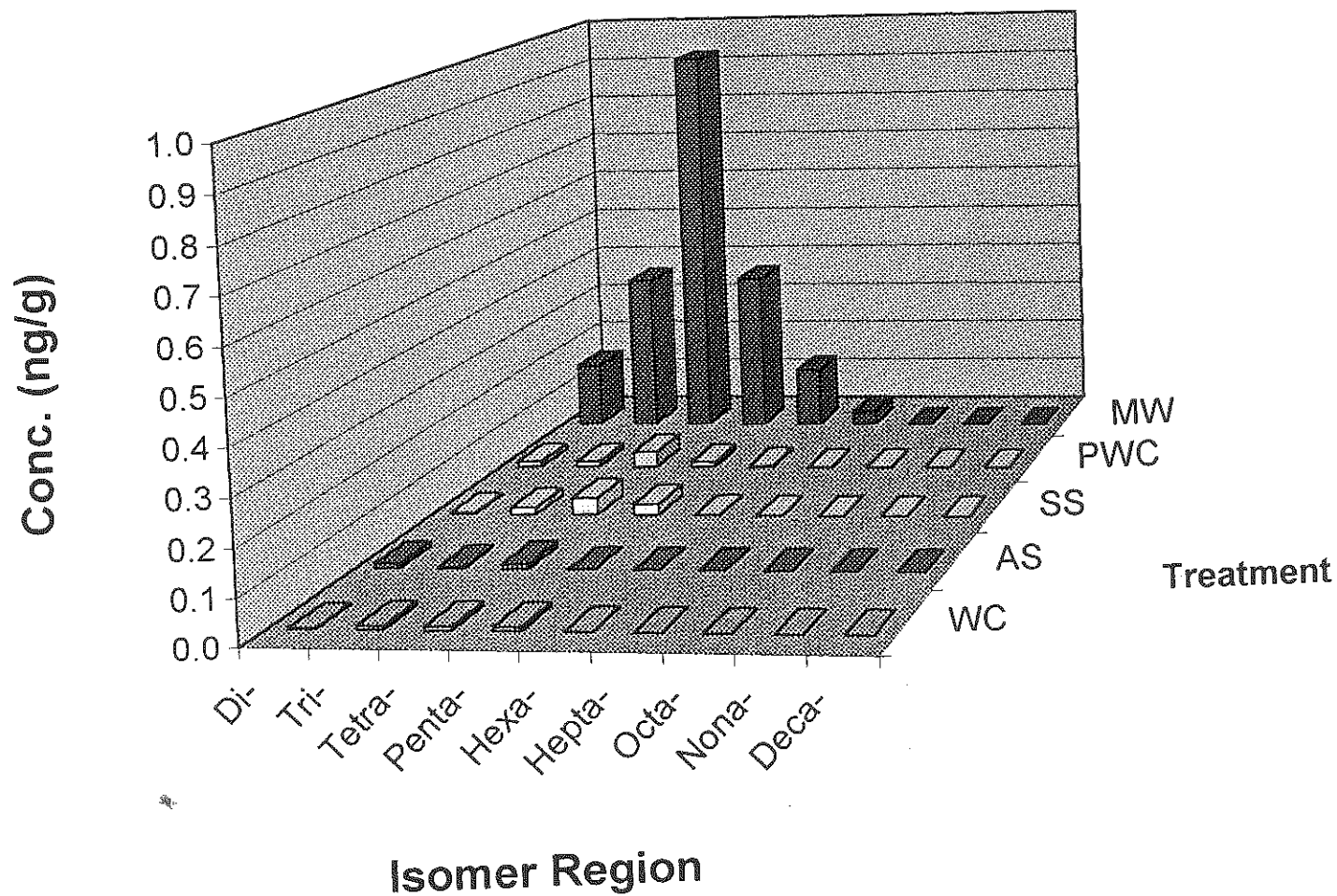
AK5 041708

**Figure 20: Sediment PCBs by Isomer Region
Dicks Creek, June 2000**



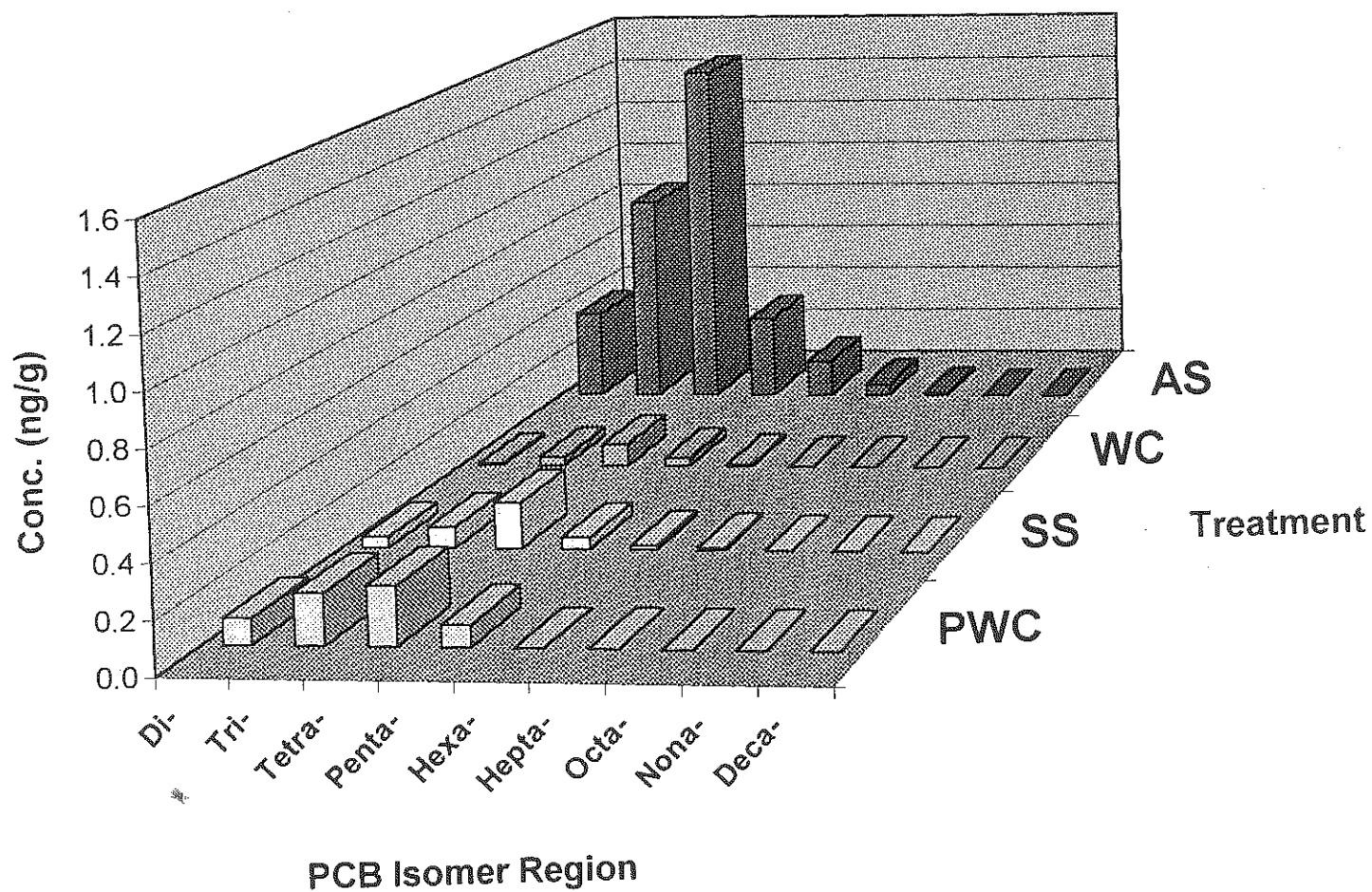
AK5 041709

Figure 21: PCB Levels in Exposure Treatments
by Isomer Region
Amanda, Dicks Creek, June 2000



AK5 041710

Figure 22: PCBs Levels in Exposure Treatment
by Isomer Regions
USGS, Dicks Creek, June 2000



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**Figure 23: Water PCB Levels in Exposure Compartments USGS,
Dicks Creek, June 2000**

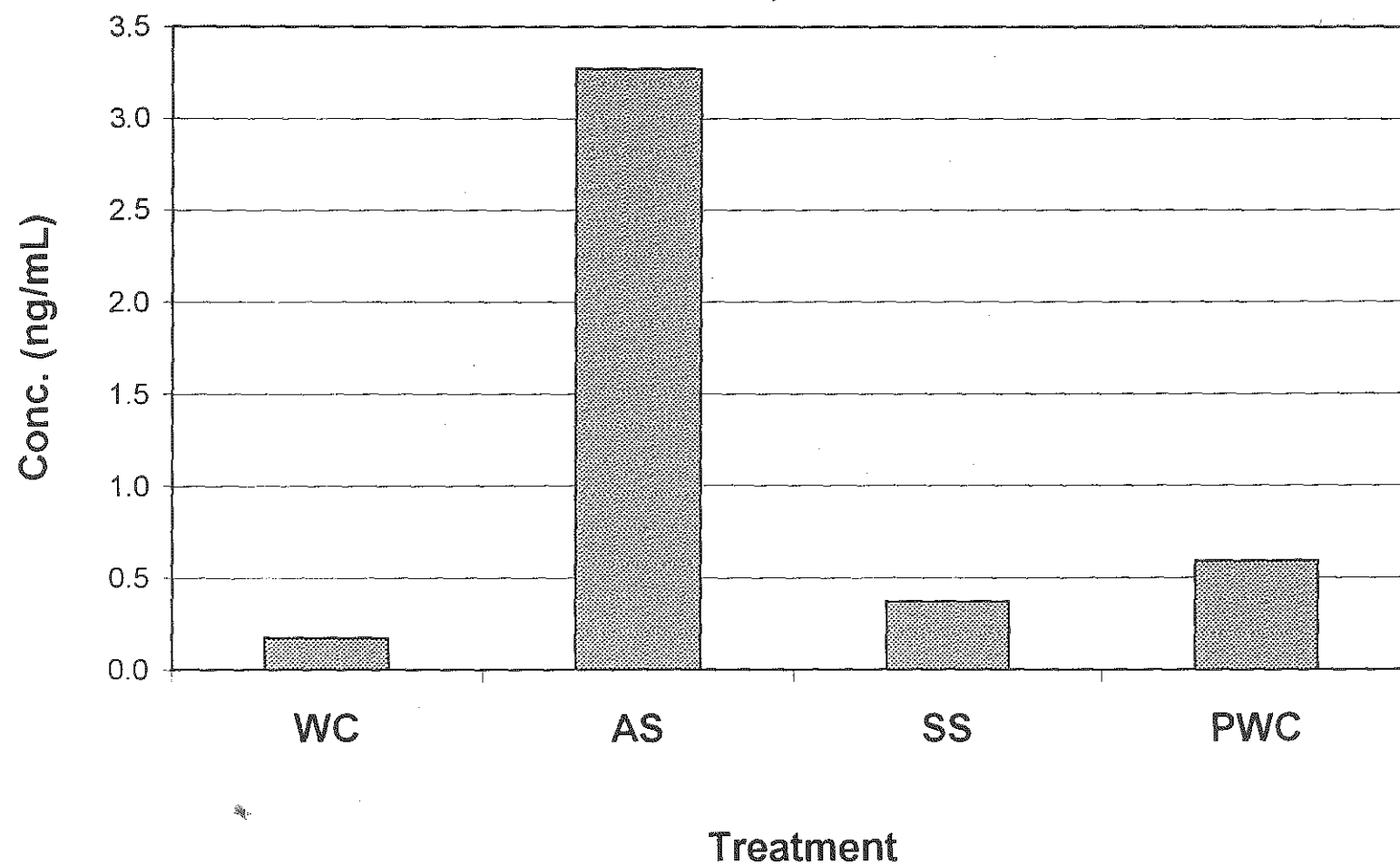
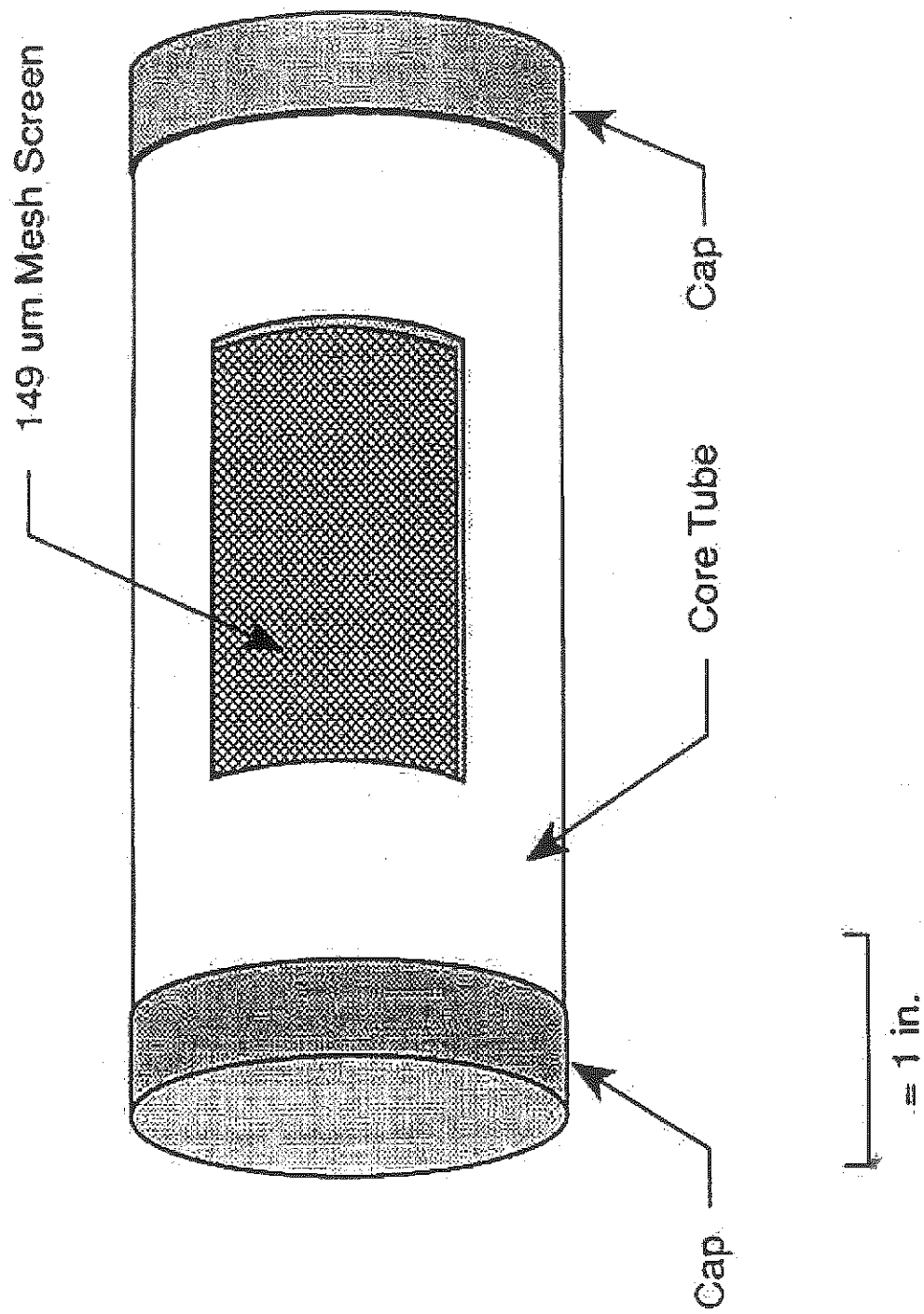


Figure 24. Basic *in situ* exposure chamber

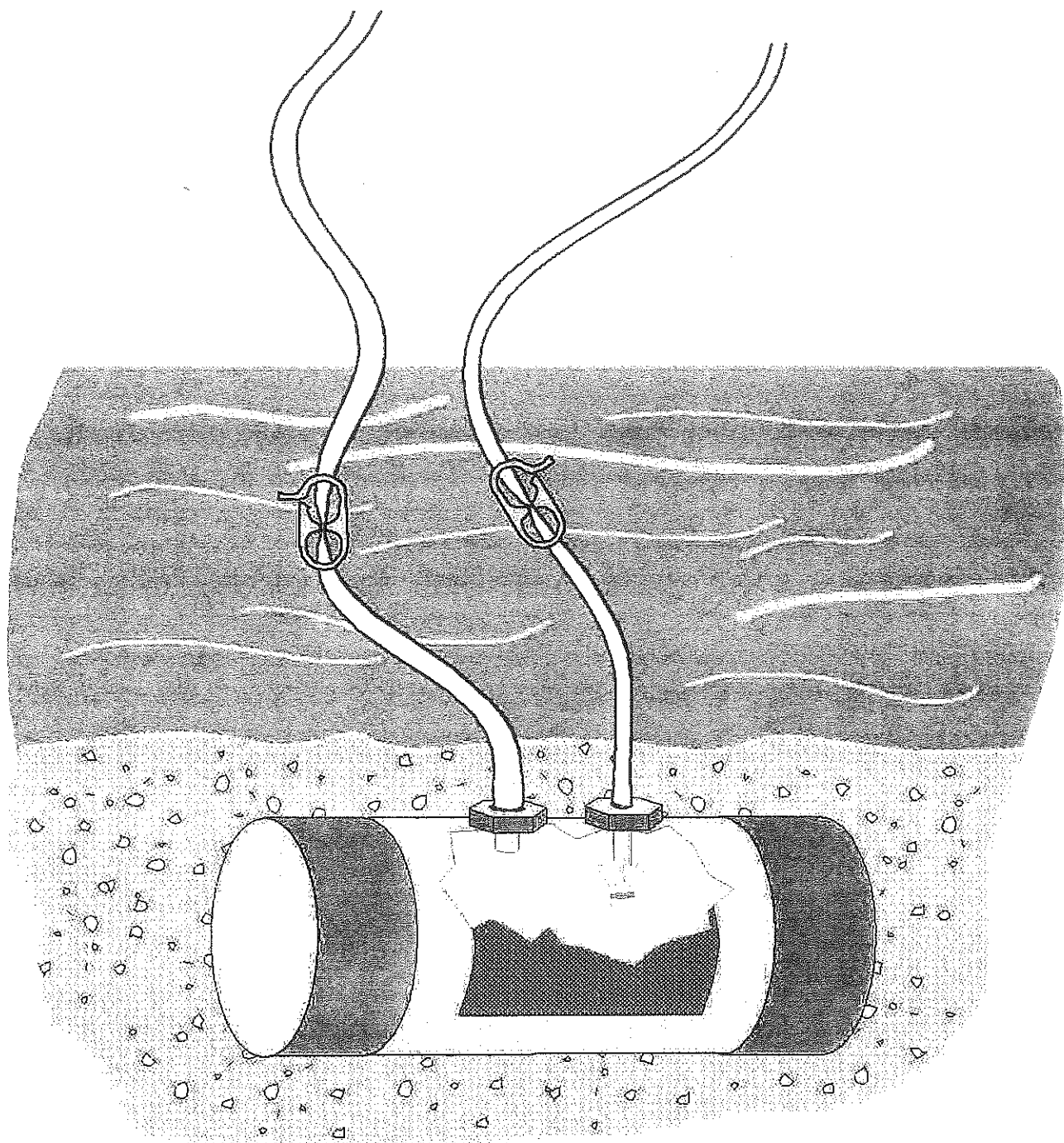


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Fig. 25 in Appendix C

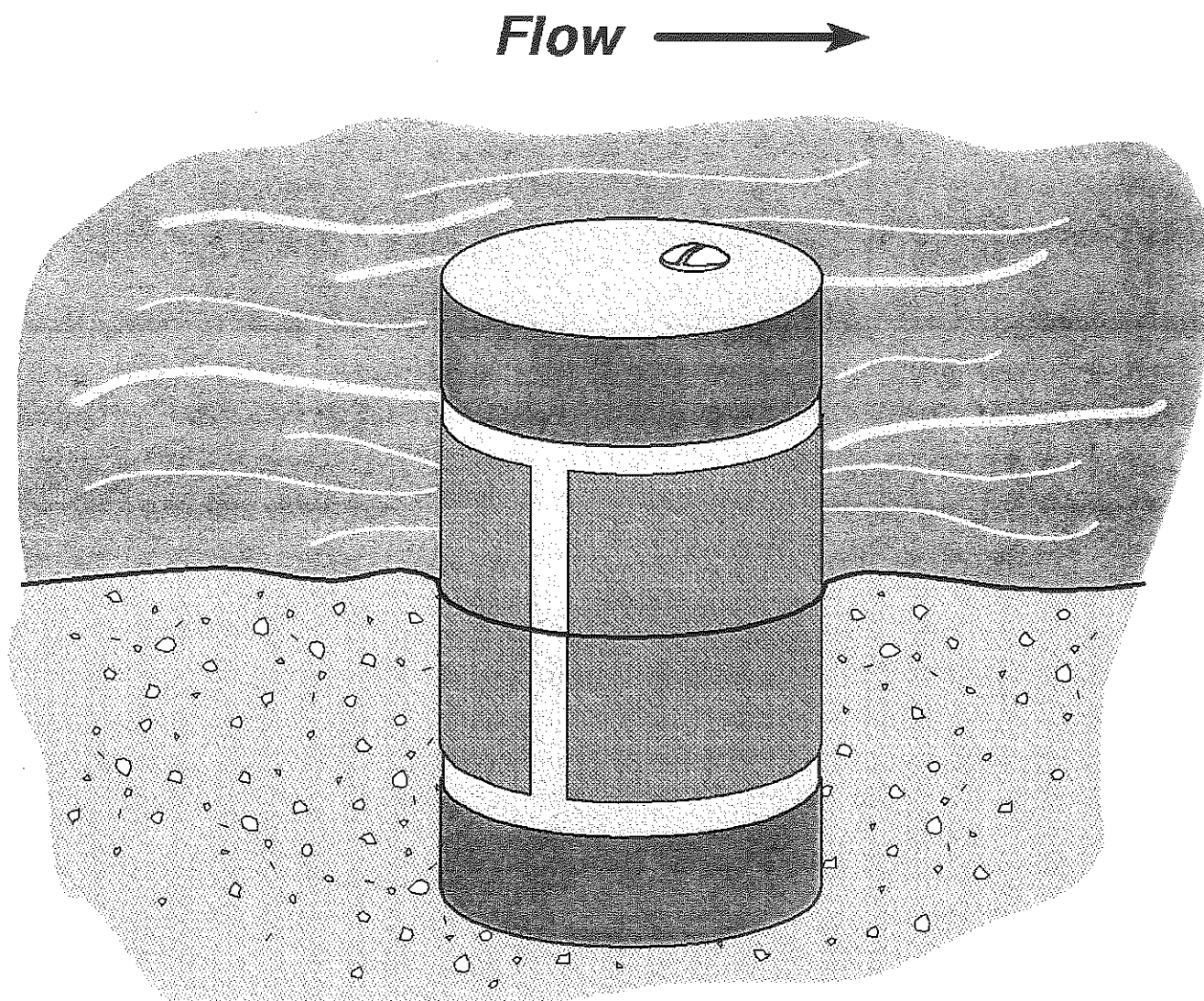
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Figure 26. *In situ* exposure chamber used for surficial sediment and pore water



AK5 041715

Figure 27. Basic *in situ* exposure chamber for *Lumbriculus variegatus*



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Appendix A

Food Web Modelling

Appendix	Title
A-1	Exposure Characterization Calculations: <i>Lumbriculus variegatus</i>
A-2	Exposure Characterization Calculations: <i>Chironomus tentans</i>
A-3	Exposure Characterization Calculations: Emergent Insects, <i>Mayfly</i>
A-4	Exposure Characterization Calculations: Omnivorous Fish
A-5	Exposure Characterization Calculations: <i>Belted Kingfisher</i>
A-6	Hazard Quotients: Invertebrates
A-7	Hazard Quotients: Emergent Insects, Mayfly
A-8	Hazard Quotients: Omnivorous fish
A-9	Hazard Quotients: Belted Kingfisher

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Appendix A1: ERA calculations for food chain:

Sediments > *Lumbriculus variegatus*

Calculations based on 1999 data

Assume the worst case scenario, thus use data from site with highest sediment contamination (Amanda)

This set of calculations was undertaken in order to compare a biologically-based modeling approach for estimation of invertebrate tissue levels to the simple approaches outlined in the SLERAP (EPA, 1999) document. This is an important concern because we have conducted a crude uncertainty analysis by varying the concentrations at the bottom of the food chain (invertebrates) and we have seen that the error is magnified with each set of equations that are used in the estimation of the COPC levels at the next highest trophic level.

Data from WSU database:

Sediment Total PCBs at Amanda 1999: 628.844 ng/g = 628.844 ug/kg = 0.629 ug/g

Sediment Total PCBs at Beaver Dam 1999: 409.160 ng/g = 409.160 ug/kg = 0.409 ug/g

Sediment Total PCBs at Confluence 1999: 10.822 ng/g = 10.822 ug/kg = 0.011 ug/g

Sediment Total PCBs at Amanda 2000: 198.168 ng/g = 198.168 ug/kg = 0.198 ug/g

Sediment Total PCBs at USGS Gauge 2000: 135.186 ng/g = 135.186 ug/kg = 0.135 ug/g

Surface Water Total PCBs at Amanda 1999: 0.035 ng/mL

Pore Water Total PCBs at Amanda 1999: 0.228 ng/mL = 0.228 ug/L

Surface Water Total PCBs at Amanda 2000: 0.019 ng/mL

Pore Water Total PCBs at Amanda 1999: 1.987 ng/mL = 1.987 ug/L

Amanda Sediment TOC = 4.26%

Estimate Concentration in Oligochaetes

Use equations developed by Thomann, R. V. 1981. Equilibrium model of the fate of microcontaminants in diverse aquatic food chains. Can. J. Fish. Aquat. Sci. 38: 280-296.

Assume that uptake is from pore water and ingested sediment

A) Parameters obtained from the literature

Oligochaete PCB uptake from water, k_u (mL/g/d) values from literature

- (1) Ram, R.N. & Gillett, J.W., Ecotoxicol. Environ. Saf. 26:166-180, 1993
 (2) Fisher, S.W. et al., Aquat. Toxicol. 45(2-3):115-126, 1999.

Citation	Type k_u value	mL/g/d	L/g/d
1	low value	249	0.249
1	low value	175	0.175
1	high value	10134	10.134
1	high value	3087	3.087
2	mono-CB	3014.4	3.0144
2	di-CB	2529.6	2.5296
2	tri-CB	3254.4	3.2544
2	tetra-CB	3213.6	3.2136
	mean	3207.125	3.207
	stdev	3080.788	3.081

Oligochaete PCB elimination, k_e (1/d) values from literature

- (1) Ram, R.N. & Gillett, J.W., Ecotoxicol. Environ. Saf. 26:166-180, 1993
 (2) Fisher, S.W. et al., Aquat. Toxicol. 45(2-3):115-126, 1999.

Citation	Type k_e value	1/d
1	low value	0.0062
1	low value	0.0111
1	high value	0.0465
1	high value	0.041
2	mono-CB	5.28
2	di-CB	0.72
2	tri-CB	0.12
2	tetra-CB	0.0312
	mean	0.782
	stdev	1.833185609

Oligochaete chem. assimilation efficiency, CAE = $72 \pm 28.1\%$
 from Morrison et al., Environ. Sci. Technol. 30:3377-3384, 1996

	%	frac
low end	43.90%	0.439
mean	72%	0.72
high end	100.10%	1

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Benthic organism food assimilation efficiency, FAE

% assimilated	frac assim.	citation
5%	0.05	Morrison et al., Environ. Sci. Technol. 30:3377-3384, 1996
20%	0.2	Thomann et al., Environ. Toxicol. Chem. 11:615-629, 1992

mean FAE = 12.500% 0.125

Oligochaete ingestion rate of sediment, IR values

g sed/g wet bw/d	citation
0.7695	Ram and Gillett (1993); sediment TOC was 3.6%
0.17	Campfens, J. and Mackay, D. 1997. Fugacity-based model of PCB bioaccumulation in complex aquatic food webs. Environ. Sci. Technol. 31:577-583
1.86	Leppanen, M.T. and Kukkonen, J.V.K., Environ. Toxicol. Chem. 17:2196-2202, 1998.

mean IR value = 0.933166667

B) Calculation of Concentration in organism, Corg (oligochaete), using parameters above

Original Thomann 1981 equation: $C_{org} = [(k_u \cdot C_w) + (CAE \cdot IR \cdot C_{food})] / k_e$; gives Corg for wet wt. of organism

Modified from Thomann (used below): $C_{org} = [(k_u \cdot C_w) + (CAE \cdot IR \cdot FAE \cdot C_{food})] / k_e$

Since oligochaetes (*Lumbriculus variegatus*) are infaunal sediment deposit feeders
use Cpw for Cw and Cs for Cfood

ku (L/g/d)	Cw (ug/L; pore water)	CAE (chem. assim. efficiency; unitless)	IR (ingest rate; g/g wet bw/d)	FAE (food assim. efficiency; unitless, frac. of ingestion)	Food PCB conc. (use Cs; ug/g)	ke (1/d)
3.207	0.228	0.720	0.933	0.125	0.629	0.782 calc with means
0.175	0.228	0.439	0.170	0.050	0.629	0.006 calc with lowest values
10.134	0.228	1.000	1.860	0.200	0.629	5.280 calc with highest values

Corg (ug/g) for oligochaete = 1.003 *using mean values for parameters*
 6.81 *using lowest values for parameters*
 0.48 *using highest values for parameters*

ku (L/g/d)	Cw (ug/L)	CAE (chem. assim. efficiency; unitless)	IR (ingest rate; g/g dry/d)	FAE (food assim. efficiency; unitless, frac. of ingestion)	Food PCB conc. (use Cs; ug/g)	ke (1/d)	
10.134	0.228	0.720	0.933	0.125	0.629	0.006	highest uptake lowest elim; all others means
10.134	0.228	0.720	0.933	0.125	0.629	5.280	highest uptake highest elim; all others means
0.175	0.228	0.720	0.933	0.125	0.629	0.006	lowest uptake lowest elim; all others means
0.175	0.228	0.720	0.933	0.125	0.629	5.280	lowest uptake highest elim; all others means

Corg (ug/g) for oligochaete = 381.19 *highest uptake lowest elim; all others means*
 0.45 *highest uptake highest elim; all others means*
 14.96 *lowest uptake lowest elim; all others means*
 0.018 *lowest uptake highest elim; all others means*

ku (L/g/d)	Cw (ug/L)	CAE (chem. assim. efficiency; unitless)	IR (ingest rate; g/g dry/d)	FAE (food assim. efficiency; unitless, frac. of ingestion)	Food PCB conc. (use Cs; ug/g)	ke (1/d)	
10.134	0.228	0.439	0.17	0.05	0.629	0.006	highest uptake lowest elim; all others lowest
10.134	0.228	0.439	0.17	0.05	0.629	5.280	highest uptake highest elim; all others lowest
0.175	0.228	0.439	0.17	0.05	0.629	0.006	lowest uptake lowest elim; all others lowest
0.175	0.228	0.439	0.17	0.05	0.629	5.280	lowest uptake highest elim; all others lowest

Corg (ug/g) for oligochaete = 373.05 *highest uptake lowest elim; all others lowest*
 0.44 *highest uptake highest elim; all others lowest*
 6.81 *lowest uptake lowest elim; all others lowest*
 0.008 *lowest uptake highest elim; all others lowest*

ku (L/g/d)	Cw (ug/L)	CAE (chem. assim. efficiency; unitless)	IR (ingest rate; g/g dry/d)	F AE (food assim. efficiency; unitless, frac. of ingestion)	Food PCB conc. (use Cs; ug/g)	ke (1/d)	
10.134	0.228	1	1.86	0.2	0.629	0.006	highest uptake lowest elim; all others highest
10.134	0.228	1	1.86	0.2	0.629	5.280	highest uptake highest elim; all others highest
0.175	0.228	1	1.86	0.2	0.629	0.006	lowest uptake lowest elim; all others highest
0.175	0.228	1	1.86	0.2	0.629	5.280	lowest uptake highest elim; all others highest
<hr/>							
Corg (ug/g) for oligochaete = 410.41			<i>highest uptake lowest elim; all others highest</i>				
0.48			<i>highest uptake highest elim; all others highest</i>				
44.18			<i>lowest uptake lowest elim; all others highest</i>				
0.05			<i>lowest uptake highest elim; all others highest</i>				

Range of values for Corg among all parameter combinations: 0.008 - 410.41 ug/g wet wt. OR 8 - 410410 ng/g wet wt.

Corg using mean parameter values: 1.003 ug/g wet wt. OR 1003 ng/g wet wt,

WSU observed *L. variegatus* tissue levels for total PCBs of 19,000 ng/g following an *in situ* exposure in the Landfill Tributary

WSU observed levels of total PCBs in indigenous oligochaetes at the same site of 8333 ng/g

1999 WSU observed Lv tissue levels at AMANDA (for WC,AS,SS,PWC exposures) of: 30.5, 104.9, 344.2, 57.9 ng/g wet wt.

1999 WSU observed Lv tissue levels at Beaver Dam (for WC,AS,SS,PWC exposures) of: 125.8, 103.1, 266.4, 105.21 ng/g wet wt.

Therefore, the calculations outlined above give realistic estimates of bioaccumulation by invertebrates such as the oligochaete worm, *Lumbriculus variegatus*.

C) Use simple toxicokinetic approach assuming both ingestion of sediment and uptake from pore water

Oligochaete PCB uptake from sediments, ks (g/g/d) values from literature

from Ram, R.N. & Gillett, J.W., *Ecotoxicol. Environ. Saf.* 26:166-180, 1993

Type	ks value	g/g/d
low		0.0265
low		0.04
high		0.1372

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high 1.679
 mean 0.471
 stdev 0.807

$$\text{Equation: } C_{org} = [(k_u \cdot C_w) + k_s \cdot C_s] / k_e$$

ku (L/g/d)	Cw (ug/L; pore water)	ks (g/g/d)	Cs (ug/g)	ke (1/d)	Corg (ug/g)	
3.207	0.228	0.471	0.629	0.782	1.314	calc with means
0.175	0.228	0.0265	0.629	0.0062	9.124	calc with lowest values
10.134	0.228	1.679	0.629	5.28	0.638	calc with highest values
10.134	0.228	0.470675	0.629	0.0062	420.420	highest ku lowest elim; mean ks
10.134	0.228	0.470675	0.629	5.28	0.494	highest ku highest elim; mean ks
0.175	0.228	0.470675	0.629	0.0062	54.186	lowest ku lowest elim; mean ks
0.175	0.228	0.470675	0.629	5.28	0.064	lowest ku highest elim; mean ks
10.134	0.228	0.0265	0.629	0.0062	375.358	highest ku lowest elim; lowest ks
10.134	0.228	0.0265	0.629	5.28	0.441	highest ku highest elim; lowest ks
0.175	0.228	0.0265	0.629	0.0062	9.124	lowest ku lowest elim; lowest ks
0.175	0.228	0.0265	0.629	5.28	0.011	lowest ku highest elim; lowest ks
10.134	0.228	1.679	0.629	0.0062	543.007	highest ku lowest elim; highest ks
10.134	0.228	1.679	0.629	5.28	0.638	highest ku highest elim; highest ks
0.175	0.228	1.679	0.629	0.0062	176.773	lowest ku lowest elim; highest ks
0.175	0.228	1.679	0.629	5.28	0.208	lowest ku highest elim; highest ks

Range of values for Corg among all parameter combinations: 0.011 - 543.007 ug/g wet wt. OR 11 - 543007 ng/g wet wt

Corg using mean parameter values: 1.314 ug/g wet wt. OR 1314 ng/g wet wt.

WSU observed *L. variegatus* tissue levels for total PCBs of 19,000 ng/g ww following an *in situ* exposure in the Landfill Tributary
 WSU observed levels of total PCBs in indigenous oligochaetes at the same site of 8333 ng/g ww

1999 WSU observed Lv tissue levels at AMANDA (for WC,AS,SS,PWC exposures) of: 30.5, 104.9, 344.2, 57.9 ng/g wet wt.

1999 WSU observed Lv tissue levels at Beaver Dam (for WC,AS,SS,PWC exposures) of: 125.8, 103.1, 266.4, 105.21 ng/g wet wt.

Therefore, the calculations outlined above give realistic estimates of bioaccumulation by invertebrates such as the oligochaete worm, *Lumbriculus variegatus*.

D) Estimate the Lv tissue conc. using literature BSAFs or BAF

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where $BSAF = Corg/Csed = (ng/g \text{ lipid})/(ng/g \text{ oc})$

BSAFs from the literature

- (1) Ankley et al., Can. J. Fish. Aquat. Sci. 49:2080-2085, 1992
- (2) Oak Ridge, BJC/OR-112
- (3) Bremle, G. and G. Ewald, Mar. Freshwater Res., 46:267-273, 1995.

$Csed, \text{ TOC-normalized} = (0.629 \text{ ug/g sed}) * (\text{g sed}/0.0426 \text{ g oc}) = 14.76 \text{ ug/g oc}$

Citation	BSAF	Cs (ug/g oc)	Corg (ug/g lipid)	Corg (ng/g lipid)
1	0.84 total PCB	14.76	12.3984	12398.4
1	0.87 total PCB	14.76	12.8412	12841.2
2	9.016 total PCB	14.76	133.07616	133076.16
2	37.193 total PCB	14.76	548.96868	548968.68
4	0.0966 total PCB	14.76	1.425816	1425.816
4	0.0932 total PCB	14.76	1.375632	1375.632
4	0.0729 total PCB	14.76	1.076004	1076.004
4	0.3146 total PCB	14.76	4.643496	4643.496
4	0.2686 total PCB	14.76	3.964536	3964.536
4	1.009 total PCB	14.76	14.89284	14892.84

BAFs are lipid-based, $BAF = (Corg/Csed) = (ug/g \text{ lipid})/(ug/g \text{ sed})$

from Bremle, G. and G. Ewald, Mar. Freshwater Res., 46:267-273, 1995.

BAF, lipid based	Cs (ug/g)	Corg (ug/g lipid)	Corg (ng/g lipid)
4.31227652 total PCB	0.629	2.712421931	2712.421931
0.88229308 total PCB	0.629	0.554962347	554.9623474
1.281965848 total PCB	0.629	0.806356518	806.3565181
6.595927117 total PCB	0.629	4.148838156	4148.838156
14.94535519 total PCB	0.629	9.400628415	9400.628415
7.161290323 total PCB	0.629	4.504451613	4504.451613

BSAF-based range from above:

1076 - 548969 ng/g lipid

NOT using the Oak Ridge values for BSAF gives a range of 1076 - 14893 ng/g lipid

BAF-lipid-based range from above:

554-9401 ng/g lipid

WSU observed Lv tissue PCBs at Amanda in 1999 that ranged from 6629.8 - 55521.4 ng/g lipid

WSU observed Lv tissue PCBs at Beaver Dam in 1999 that ranged from 12093 - 70118 ng/g lipid

Using 1999 Lv data from sediment exposures only, the BSAFs for Dicks Creek sediments is as follows

Site	Treatment	Lv, ng PCB/g lipid	Sed, ng/g oc	BSAF
Amanda	AS	16915.17	14761.6	1.146
Amanda	SS	55521.4	14761.6	3.761
Amanda	PWC	7718.31	14761.6	0.523
Beaver Dam	AS	46890	10518.3	4.458
Beaver Dam	SS	70117.9	10518.3	6.666
Beaver Dam	PWC	12093	10518.3	1.150
Confluence	AS	1578.42	181.3	8.706
Confluence	SS	2976.7	181.3	16.419
Confluence	PWC	597.6	181.3	3.296

BCFs for oligochaetes from the literature

(1) Connell, D. W., et al., Ecotoxicol. Environ. Saf. 16: 293-302, 1988.

Citation	congener	BCF	Cw (pore water; ug/L)	Corg (ug/kg = ng/g)
1	TriCB	9970	0.228	2273.16
1	TriCB	13300	0.228	3032.4
1	TetraCB	94200	0.228	21477.6
1	TetraCB	1180000	0.228	269040
1	TetraCB	66300	0.228	15116.4
1	TetraCB	815000	0.228	185820
1	PentaCB	243000	0.228	55404
1	PentaCB	440000	0.228	100320
1	HexaCB	1095000	0.228	249660
1	HexaCB	1910000	0.228	435480
1	OctaCB	1870000	0.228	426360
1	OctaCB	2200000	0.228	501600

see if these BCF values
were derived from lipid based
tissue concentrations,
if so that's why these seem to be
so high

AK5 041725

Appendix A1: ERA calculations for food chain:

Sediments > *Lumbriculus variegatus*

Calculations based on June 2000 data

Assume the worst case scenario, thus use data from site with highest sediment contamination (Amanda)

This set of calculations was undertaken in order to compare a biologically-based modeling approach for estimation of invertebrate tissue levels to the simple approaches outlined in the SLERAP (EPA, 1999) document. This is an important concern because we have conducted a crude uncertainty analysis by varying the concentrations at the bottom of the food chain (invertebrates) and we have seen that the error is magnified with each set of equations that are used in the estimation of the COPC levels at the next highest trophic level.

Data from WSU database:

Sediment Total PCBs at Amanda 1999: 628.844 ng/g = 628.844 ug/kg = 0.629 ug/g

Sediment Total PCBs at Beaver Dam 1999: 409.160 ng/g = 409.160 ug/kg = 0.409 ug/g

Sediment Total PCBs at Confluence 1999: 10.822 ng/g = 10.822 ug/kg = 0.011 ug/g

Sediment Total PCBs at Amanda 2000: 198.168 ng/g = 198.168 ug/kg = 0.198 ug/g

Sediment Total PCBs at USGS Gauge 2000: 135.186 ng/g = 135.186 ug/kg = 0.135 ug/g

Surface Water Total PCBs at Amanda 1999: 0.035 ng/mL

Pore Water Total PCBs at Amanda 1999: 0.228 ng/mL = 0.228 ug/L

Surface Water Total PCBs at Amanda 2000: 0.019 ng/mL

Pore Water Total PCBs at Amanda 1999: 1.987 ng/mL = 1.987 ug/L

Amanda Sediment TOC = 4.26%

Estimate Concentration in Oligochaetes

Use equations developed by Thomann, R. V. 1981. Equilibrium model of the fate of microcontaminants in diverse aquatic food chains. Can. J. Fish. Aquat. Sci. 38: 280-296.

Assume that uptake is from pore water and ingested sediment

AK5 041726

A) Parameters obtained from the literature

Oligochaete PCB uptake from water, k_u (mL/g/d) values from literature

- (1) Ram, R.N. & Gillett, J.W., Ecotoxicol. Environ. Saf. 26:166-180, 1993
 (2) Fisher, S.W. et al., Aquat. Toxicol. 45(2-3):115-126, 1999.

Citation	Type k_u value	mL/g/d	L/g/d
1	low value	249	0.249
1	low value	175	0.175
1	high value	10134	10.134
1	high value	3087	3.087
2	mono-CB	3014.4	3.0144
2	di-CB	2529.6	2.5296
2	tri-CB	3254.4	3.2544
2	tetra-CB	3213.6	3.2136
	mean	3207.125	3.207
	stdev	3080.788	3.081

Oligochaete PCB elimination, k_e (1/d) values from literature

- (1) Ram, R.N. & Gillett, J.W., Ecotoxicol. Environ. Saf. 26:166-180, 1993
 (2) Fisher, S.W. et al., Aquat. Toxicol. 45(2-3):115-126, 1999.

Citation	Type k_e value	1/d
1	low value	0.0062
1	low value	0.0111
1	high value	0.0465
1	high value	0.041
2	mono-CB	5.28
2	di-CB	0.72
2	tri-CB	0.12
2	tetra-CB	0.0312
	mean	0.782
	stdev	1.833185609

Oligochaete chem. assimilation efficiency, CAE = $72 \pm 28.1\%$

AK5 041727

from Morrison et al., Environ. Sci. Technol. 30:3377-3384, 1996

	%	frac
low end	43.90%	0.439
mean	72%	0.72
high end	100.10%	1

Benthic organism food assimilation efficiency, FAE

% assimilated	frac assim.	citation
5%	0.05	Morrison et al., Environ. Sci. Technol. 30:3377-3384, 1996
20%	0.2	Thomann et al., Environ. Toxicol. Chem. 11:615-629, 1992

mean FAE = 12.500% 0.125

Oligochaete ingestion rate of sediment, IR values

g sed/g wet bw/d	citation
0.7695	Ram and Gillett (1993); sediment TOC was 3.6%
0.17	Campfens, J. and Mackay, D. 1997. Fugacity-based model of PCB bioaccumulation in complex aquatic food webs. Environ. Sci. Technol. 31:577-583
1.86	Leppanen, M.T. and Kukkonen, J.V.K., Environ. Toxicol. Chem. 17:2196-2202, 1998.

mean IR value = 0.933166667

B) Calculation of Concentration in organism, Corg (oligochaete), using parameters above

Original Thomann 1981 equation: $C_{org} = [(k_u \cdot C_w) + (CAE \cdot IR \cdot C_{food})] / k_e$; gives Corg for wet wt. of organism

Modified from Thomann (used below): $C_{org} = [(k_u \cdot C_w) + (CAE \cdot IR \cdot FAE \cdot C_{food})] / k_e$

Since oligochaetes (*Lymbriculus variegatus*) are infaunal sediment deposit feeders
use Cpw for Cw and Cs for Cfood

AK5 041728

ku (L/g/d)	Cw (ug/L; pore water)	CAE (chem. assim. efficiency; unitless)	IR (ingest rate; g/g wet bw/d)	FAE (food assim. efficiency; unitless, frac. of ingestion)	Food PCB conc. (use Cs; ug/g)	ke (1/d)
3.207	1.987	0.720	0.933	0.125	0.198	0.782 calc with means
0.175	1.987	0.439	0.170	0.050	0.198	0.006 calc with lowest values
10.134	1.987	1.000	1.860	0.200	0.198	5.280 calc with highest values
Corg (ug/g) for oligochaete = 8.170 <i>using mean values for parameters</i>						
56.20 <i>using lowest values for parameters</i>						
3.83 <i>using highest values for parameters</i>						

ku (L/g/d)	Cw (ug/L)	CAE (chem. assim. efficiency; unitless)	IR (ingest rate; g/g dry/d)	FAE (food assim. efficiency; unitless, frac. of ingestion)	Food PCB conc. (use Cs; ug/g)	ke (1/d)
10.134	1.987	0.720	0.933	0.125	0.198	0.006 highest uptake lowest elim; all others means
10.134	1.987	0.720	0.933	0.125	0.198	5.280 highest uptake highest elim; all others means
0.175	1.987	0.720	0.933	0.125	0.198	0.006 lowest uptake lowest elim; all others means
0.175	1.987	0.720	0.933	0.125	0.198	5.280 lowest uptake highest elim; all others means
Corg (ug/g) for oligochaete = 3250.47 <i>highest uptake lowest elim; all others means</i>						
3.82 <i>highest uptake highest elim; all others means</i>						
58.77 <i>lowest uptake lowest elim; all others means</i>						
0.069 <i>lowest uptake highest elim; all others means</i>						

AK5 041729

ku (L/g/d)	Cw (ug/L)	CAE (chem. assim. efficiency; unitless)	IR (ingest rate; g/g dry/d)	FAE (food assim. efficiency; unitless, frac. of ingestion)	Food PCB conc. (use Cs; ug/g)	ke (1/d)	
10.134	1.987	0.439	0.17	0.05	0.198	0.006	highest uptake lowest elim; all others lowest
10.134	1.987	0.439	0.17	0.05	0.198	5.280	highest uptake highest elim; all others lowest
0.175	1.987	0.439	0.17	0.05	0.198	0.006	lowest uptake lowest elim; all others lowest
0.175	1.987	0.439	0.17	0.05	0.198	5.280	lowest uptake highest elim; all others lowest
<hr/>							
Corg (ug/g) for oligochaete = 3247.90							<i>highest uptake lowest elim; all others lowest</i>
3.81							<i>highest uptake highest elim; all others lowest</i>
56.20							<i>lowest uptake lowest elim; all others lowest</i>
0.066							<i>lowest uptake highest elim; all others lowest</i>

ku (L/g/d)	Cw (ug/L)	CAE (chem. assim. efficiency; unitless)	IR (ingest rate; g/g dry/d)	FAE (food assim. efficiency; unitless, frac. of ingestion)	Food PCB conc. (use Cs; ug/g)	ke (1/d)	
10.134	1.987	1	1.86	0.2	0.198	0.006	highest uptake lowest elim; all others highest
10.134	1.987	1	1.86	0.2	0.198	5.280	highest uptake highest elim; all others highest
0.175	1.987	1	1.86	0.2	0.198	0.006	lowest uptake lowest elim; all others highest
0.175	1.987	1	1.86	0.2	0.198	5.280	lowest uptake highest elim; all others highest
<hr/>							
Corg (ug/g) for oligochaete = 3259.66							<i>highest uptake lowest elim; all others highest</i>
3.83							<i>highest uptake highest elim; all others highest</i>
67.96							<i>lowest uptake lowest elim; all others highest</i>
0.08							<i>lowest uptake highest elim; all others highest</i>

Range of values for Corg among all parameter combinations: 0.066 - 3260 ug/g wet wt. OR 66 - 3260000 ng/g wet wt.

Corg using mean parameter values: 8.170 ug/g wet wt. OR 8170 ng/g wet wt,

WSU observed *L. variegatus* tissue levels for total PCBs of 19,000 ng/g following an *in situ* exposure in the Landfill Tributary

AK5 041730

WSU observed levels of total PCBs in indigenous oligochaetes at the same site of 8333 ng/g

2000 WSU observed Lv tissue levels at AMANDA (for WC,AS,SS,PWC exposures) of: 238.3, 206, 26.1, 677 ng/g wet wt.

2000 WSU observed Lv tissue levels at USGS (for WC,AS,SS,PWC exposures) of: 249.5, 353.6, 1469.872, 536.3 ng/g wet wt.

Therefore, the calculations outlined above give realistic estimates of bioaccumulation by invertebrates such as the oligochaete worm, *Lumbriculus variegatus*

C) Use simple toxicokinetic approach assuming both ingestion of sediment and uptake from pore water

Oligochaete PCB uptake from sediments, k_s (g/g/d) values from literature

from Ram, R.N. & Gillett, J.W., Ecotoxicol. Environ. Saf. 26:166-180, 1993

Type k_s value	g/g/d
low	0.0265
low	0.04
high	0.1372
high	1.679
mean	0.471
stdev	0.807

$$\text{Equation: } C_{org} = [(k_u \cdot C_w) + k_s \cdot C_s] / k_e$$

k_u (L/g/d)	C_w (ug/L; pore water)	k_s (g/g/d)	C_s (ug/g)	k_e (1/d)	C_{org} (ug/g)	
3.207	1.987	0.471	0.198	0.782	8.268	calc with means
0.175	1.987	0.0265	0.198	0.0062	56.931	calc with lowest values
10.134	1.987	1.679	0.198	5.28	3.877	calc with highest values
10.134	1.987	0.470675	0.198	0.0062	3262.815	highest k_u lowest elim; mean k_s
10.134	1.987	0.470675	0.198	5.28	3.831	highest k_u highest elim; mean k_s
0.175	1.987	0.470675	0.198	0.0062	71.116	lowest k_u lowest elim; mean k_s
0.175	1.987	0.470675	0.198	5.28	0.084	lowest k_u highest elim; mean k_s
10.134	1.987	0.0265	0.198	0.0062	3248.630	highest k_u lowest elim; lowest k_s
10.134	1.987	0.0265	0.198	5.28	3.815	highest k_u highest elim; lowest k_s
0.175	1.987	0.0265	0.198	0.0062	56.931	lowest k_u lowest elim; lowest k_s
0.175	1.987	0.0265	0.198	5.28	0.067	lowest k_u highest elim; lowest k_s

AK5 041731

10.134	1.987	1.679	0.198	0.0062	3301.403	highest ku lowest elim; highest ks
10.134	1.987	1.679	0.198	5.28	3.877	highest ku highest elim; highest ks
0.175	1.987	1.679	0.198	0.0062	109.704	lowest ku lowest elim; highest ks
0.175	1.987	1.679	0.198	5.28	0.129	lowest ku highest elim; highest ks

Range of values for Corg among all parameter combinations: 0.067 - 3301.403 ug/g wet wt. OR 67 - 3301403 ng/g wet wt
 Corg using mean parameter values: 8.268 ug/g wet wt. OR 8268 ng/g wet wt.

WSU observed *L. variegatus* tissue levels for total PCBs of 19,000 ng/g ww following an *in situ* exposure in the Landfill Tributary
 WSU observed levels of total PCBs in indigenous oligochaetes at the same site of 8333 ng/g ww

2000 WSU observed Lv tissue levels at AMANDA (for WC,AS,SS,PWC exposures) of: 238.3, 206, 26.1, 677 ng/g wet wt.
 2000 WSU observed Lv tissue levels at USGS (for WC,AS,SS,PWC exposures) of: 249.5, 353.6, 1469.879, 536.3 ng/g wet wt.

Therefore, the calculations outlined above give realistic estimates of bioaccumulation by invertebrates such as the oligochaete worm, *Lumbriculus variegatus*

D) Estimate the Lv tissue conc. using literature BSAFs, BAF or BCF

where BSAF = Corg/Csed = (ng/g lipid)/(ng/g oc)

BSAFs from the literature

- (1) Ankley et al., Can. J. Fish. Aquat. Sci. 49:2080-2085, 1992
- (2) Oak Ridge, BJC/OR-112
- (3) Bremle, G. and G. Ewald, Mar. Freshwater Res., 46:267-273, 1995.

Csed, TOC-normalized = (0.629 ug/g sed) * (g sed/0.0426 g oc) = 14.76 ug/g oc

Citation	BSAF	Cs (ug/g oc)	Corg (ug/g lipid)	Corg (ng/g lipid)
1	0.84 total PCB	4.652	3.90768	3907.68
1	0.87 total PCB	4.652	4.04724	4047.24
2	9.016 total PCB	4.652	41.942432	41942.432
2	37.193 total PCB	4.652	173.021836	173021.836
4	0.0966 total PCB	4.652	0.4493832	449.3832
4	0.0932 total PCB	4.652	0.4335664	433.5664
4	0.0729 total PCB	4.652	0.3391308	339.1308

AK5 041732

Appendix A1 cont.

4	0.3146 total PCB	4.652	1.4635192	1463.5192
4	0.2686 total PCB	4.652	1.2495272	1249.5272
4	1.009 total PCB	4.652	4.693868	4693.868

BAFs are lipid-based, $BAF = (C_{org}/C_{sed}) = (ug/g \text{ lipid})/(ug/g \text{ sed})$

from Bremle, G. and G. Ewald, Mar. Freshwater Res., 46:267-273, 1995.

BAF, lipid based	Cs (ug/g)	Corg (ug/g lipid)	Corg (ng/g lipid)
4.31227652 total PCB	0.198	0.853830751	853.8307509
0.88229308 total PCB	0.198	0.17469403	174.6940299
1.281965848 total PCB	0.198	0.253829238	253.8292378
6.595927117 total PCB	0.198	1.305993569	1305.993569
14.94535519 total PCB	0.198	2.959180328	2959.180328
7.161290323 total PCB	0.198	1.417935484	1417.935484

BSAF-based range from above: 339.1 - 173022 ng/g lipid

NOT using the Oak Ridge values for BSAF gives a range of 339.1 - 4694 ng/g lipid

BAF-lipid-based range from above: 175 - 2959 ng/g lipid

WSU observed Lv tissue PCBs at Amanda in June 2000 that ranged from 5216.6 - 130116 ng/g lipid

WSU observed Lv tissue PCBs at USGS in June 2000 that ranged from 20112 - 94222.564 ng/g lipid

Using 1999 Lv data from sediment exposures only, the BSAFs for Dicks Creek sediments is as follows

Site	Treatment	Lv, ng PCB/g lipid	Sed, ng/g oc	BSAF
Amanda	AS	30294	4651.831	6.512
Amanda	SS	5216.6	4651.831	1.121
Amanda	PWC	130116	4651.831	27.971
USGS	AS	20803	3475.219	5.986
USGS	SS	94222.564	3475.219	27.113
USGS	PWC	32506	3475.219	9.354

AK5 041733

BCFs for oligochaetes from the literature

(1) Connell, D. W., et al., Ecotoxicol. Environ. Saf. 16: 293-302, 1988.

Citation	congener	BCF	Cw (pore water; ug/L)	Corg (ug/kg = ng/g)
1	TriCB	9970	1.987	19810.39
1	TriCB	13300	1.987	26427.1
1	TetraCB	94200	1.987	187175.4
1	TetraCB	1180000	1.987	2344660
1	TetraCB	66300	1.987	131738.1
1	TetraCB	815000	1.987	1619405
1	PentaCB	243000	1.987	482841
1	PentaCB	440000	1.987	874280
1	HexaCB	1095000	1.987	2175765
1	HexaCB	1910000	1.987	3795170
1	OctaCB	1870000	1.987	3715690
1	OctaCB	2200000	1.987	4371400

see if these BCF values
were derived from lipid based
tissue concentrations,
if so that's why these seem to be
so high

AK5 041734

Appendix A2: ERA calculations for food chain:

Sediments > *Chironomus tentans*

Calculations based on 1999 data

Assume the worst case scenario, thus use data from site with highest sediment contamination (Amanda)

Data from WSU database:

Sediment Total PCBs at Amanda 1999: 628.844 ng/g = 628.844 ug/kg = 0.629 ug/g

Sediment Total PCBs at Beaver Dam 1999: 409.160 ng/g = 409.160 ug/kg = 0.409 ug/g

Sediment Total PCBs at Confluence 1999: 10.822 ng/g = 10.822 ug/kg = 0.011 ug/g

Sediment Total PCBs at Amanda 2000: 198.168 ng/g = 198.168 ug/kg = 0.198 ug/g

Sediment Total PCBs at USGS Gauge 2000: 135.186 ng/g = 135.186 ug/kg = 0.135 ug/g

Surface Water Total PCBs at Amanda 1999: 0.035 ng/mL

Pore Water Total PCBs at Amanda 1999: 0.228 ng/mL = 0.228 ug/L

Surface Water Total PCBs at Amanda 2000: 0.019 ng/mL

Pore Water Total PCBs at Amanda 1999: 1.987 ng/mL = 1.987 ug/L

Amanda Sediment TOC = 4.26%

Estimate Concentration in midges

Use equations developed by Thomann, R. V. 1981. Equilibrium model of the fate of microcontaminants in diverse aquatic food chains. Can. J. Fish. Aquat. Sci. 38: 280-296.

Assume that uptake is from pore water and ingested sediment

A) Parameters obtained from the literature

Midge PCB uptake from water, k_u (mL/g/d) values from literature

Lydy, M.J. et al., Arch. Environ. Contam. Toxicol. 38:163-168, 2000.

Compound	Type k_u value	mL/g/h	L/g/d
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AK5 041735

2-CB	- 1 SD	63.87	1.533
2-CB	mean	65.96	1.583
2-CB	+ 1 SD	68.05	1.633

Midge PCB elimination, k_e (1/d) values from literature

Lydy, M.J. et al., Arch. Environ. Contam. Toxicol. 38:163-168, 2000.

Compound	Type	k_e value	k_{ep} (elim parent; 1/d)	k_m (biotrans rate; 1/d)	k_e ($k_{ep}+k_m$; 1/d)
2-CB	- 1 SD		2.208	0.624	2.832
2-CB	mean		2.4	0.744	3.144
2-CB	+ 1 SD		2.592	0.864	3.456

Benthic organism chem. assimilation efficiency, CAE = $72 \pm 28.1\%$

from Morrison et al., Environ. Sci. Technol. 30:3377-3384, 1996

	%	frac
low end	43.90%	0.439
mean	72%	0.72
high end	100.10%	1

Benthic organism food assimilation efficiency, FAE

Organisms	% assimilated	frac assim.	citation
benthos	5.0%	0.05	Morrison et al., Environ. Sci. Technol. 30:3377-3384, 1996
benthos	20.0%	0.2	Thomann et al., Environ. Toxicol. Chem. 11:615-629, 1992
midge	11.9%	0.119	Rasmussen, J. B., Can. J. Zool. 62:1022-1026, 1984
midge	5.9%	0.059	Rasmussen, J. B., Can. J. Zool. 62:1022-1026, 1984

mean FAE = 10.700% 0.107

Midge ingestion rate, IR values

g food/g wet

bw/d	citation
0.048	Liber, K. et al., Hydrobiologia 323:155-167, 1996
0.0505	Liber, K. et al., Hydrobiologia 323:155-167, 1996

AK5 041736

0.094 Sibley, P. K. et al., Environ. Toxicol. Chem. 16(2):336-345, 1997

mean IR value = 0.064166667

B) Calculation of Concentration in organism, Corg (midge), using parameters above

Original Thomann 1981 equation: $C_{org} = [(k_u \cdot C_w) + (CAE \cdot IR \cdot C_{food})] / k_e$; gives Corg for wet wt. of organism

Modified from Thomann (used below): $C_{org} = [(k_u \cdot C_w) + (CAE \cdot IR \cdot FAE \cdot C_{food})] / k_e$

use Cpw for Cw and Cs for Cfood

ku (L/g/d)	Cw (ug/L; pore water)	CAE (chem. assim. efficiency; unitless)	IR (ingest rate; g/g wet bw/d)	FAE (food assim. efficiency; unitless, frac. of ingestion)	Food PCB conc. (use Cs; ug/g)	ke (1/d)
1.583	0.228	0.720	0.064	0.107	0.629	3.144 calc with means
1.533	0.228	0.439	0.048	0.050	0.629	2.832 calc with lowest values
1.633	0.228	1.000	0.094	0.200	0.629	3.456 calc with highest values
Corg (ug/g) for midge = 0.116						
			using mean values for parameters			
0.12			using lowest values for parameters			
0.11			using highest values for parameters			

ku (L/g/d)	Cw (ug/L)	CAE (chem. assim. efficiency; unitless)	IR (ingest rate; g/g dry/d)	FAE (food assim. efficiency; unitless, frac. of ingestion)	Food PCB conc. (use Cs; ug/g)	ke (1/d)
1.633	0.228	0.720	0.064	0.107	0.629	2.832 highest uptake lowest elim; all others means
1.633	0.228	0.720	0.064	0.107	0.629	3.456 highest uptake highest elim; all others means

Appendix A2

1.533	0.228	0.720	0.064	0.107	0.629	2.832	lowest uptake lowest elim; all others means
1.533	0.228	0.720	0.064	0.107	0.629	3.456	lowest uptake highest elim; all others means

Corg (ug/g) for midge = 0.133	<i>highest uptake lowest elim; all others means</i>
0.109	<i>highest uptake highest elim; all others means</i>
0.125	<i>lowest uptake lowest elim; all others means</i>
0.102	<i>lowest uptake highest elim; all others means</i>

ku (L/g/d)	Cw (ug/L)	CAE (chem. assim. efficiency; unitless)	IR (ingest rate; g/g dry/d)	F AE (food assim. efficiency; unitless, frac. of ingestion)	Food PCB conc. (use Cs; ug/g)	ke (1/d)	
1.633	0.228	0.439	0.048	0.05	0.629	2.832	highest uptake lowest elim; all others lowest
1.633	0.228	0.439	0.048	0.05	0.629	3.456	highest uptake highest elim; all others lowest
1.533	0.228	0.439	0.048	0.05	0.629	2.832	lowest uptake lowest elim; all others lowest
1.533	0.228	0.439	0.048	0.05	0.629	3.456	lowest uptake highest elim; all others lowest

Corg (ug/g) for midge = 0.132	<i>highest uptake lowest elim; all others lowest</i>
0.108	<i>highest uptake highest elim; all others lowest</i>
0.124	<i>lowest uptake lowest elim; all others lowest</i>
0.101	<i>lowest uptake highest elim; all others lowest</i>

ku (L/g/d)	Cw (ug/L)	CAE (chem. assim. efficiency; unitless)	IR (ingest rate; g/g dry/d)	F AE (food assim. efficiency; unitless, frac. of ingestion)	Food PCB conc. (use Cs; ug/g)	ke (1/d)	
1.633	0.228	1	0.094	0.2	0.629	2.832	highest uptake lowest elim; all others highest
1.633	0.228	1	0.094	0.2	0.629	3.456	highest uptake highest elim; all others highest
1.533	0.228	1	0.094	0.2	0.629	2.832	lowest uptake lowest elim; all others highest
1.533	0.228	1	0.094	0.2	0.629	3.456	lowest uptake highest elim; all others highest

Corg (ug/g) for midge = 0.136	<i>highest uptake lowest elim; all others highest</i>
0.111	<i>highest uptake highest elim; all others highest</i>
0.128	<i>lowest uptake lowest elim; all others highest</i>
0.105	<i>lowest uptake highest elim; all others highest</i>

Range of values for Corg among all parameter combinations: 0.101 - 0.136 ug/g wet wt. OR 101 - 136 ng/g wet wt.

Corg using mean parameter values: 0.116 ug/g wet wt. OR 116 ng/g wet wt,

WSU observed *L. variegatus* tissue levels for total PCBs of 19,000 ng/g following an *in situ* exposure in the Landfill Tributary

WSU observed levels of total PCBs in indigenous oligochaetes at the same site of 8333 ng/g

2000 WSU observed Ct tissue levels at USGS (AS & SS exposures) of: 94,342 and 7434.862 ng/g wet wt.

Therefore, the calculations outlined above lie within the range of recent (year 2000) field measurements.

C) Estimate the Lv tissue conc. using literature BSAFs, BAF or BCF

where BSAF = Corg/Csed = (ng/g lipid)/(ng/g oc)

BSAFs from the literature

(1) Oak Ridge, BJC/OR-112

(2) Bremle, G. and G. Ewald, Mar. Freshwater Res., 46:267-273, 1995.

Csed, TOC-normalized = (0.629 ug/g sed) * (g sed/0.0426 g oc) = 14.76 ug/g oc

Citation	BSAF	Cs (ug/g oc)	Corg (ug/g lipid)	Corg (ng/g lipid)
1	9.016 total PCB	14.762	133.094	133094.192
1	37.193 total PCB	14.762	549.043	549043.066
2	0.114480293 total PCB	14.762	1.690	1690.047
2	0.26303488 total PCB	14.762	3.883	3882.921
2	0.118185049 total PCB	14.762	1.745	1744.648
2	0.422839033 total PCB	14.762	6.242	6241.950
2	0.449813396 total PCB	14.762	6.640	6640.145
2	2.406493506 total PCB	14.762	35.525	35524.657

AK5 041739

BAFs are lipid-based, $BAF = (C_{org}/C_{sed}) = (ug/g \text{ lipid})/(ug/g \text{ sed})$

from Bremle, G. and G. Ewald, Mar. Freshwater Res., 46:267-273, 1995.

BAF, lipid based	Cs (ug/g)	Corg (ug/g lipid)	Corg (ng/g lipid)
5.112038141 total PCB	0.629	3.215	3215.472
2.481343284 total PCB	0.629	1.561	1560.765
2.077467722 total PCB	0.629	1.307	1306.727
8.86602358 total PCB	0.629	5.577	5576.729
25.0273224 total PCB	0.629	15.742	15742.186
17.07834101 total PCB	0.629	10.742	10742.276

BSAF-based range from above: 1690 - 549043 ng/g lipid

BAF-lipid-based range from above: 1306 - 15742 ng/g lipid

WSU observed Ct tissue PCBs at USGS in 2000 that ranged from 3145 - 189665 ng/g lipid

BCFs for *Chironomus tentans* from the literature:

- (1) Wood, L. W. et al., Water Res. 21:875-884, 1987
- (2) Lydy, M.J. et al., Arch. Environ. Contam. Toxicol. 38:163-168, 2000.

Citation	congener	BCF	Cw (pore water; ug/L)	Corg (ug/kg = ng/g)
1	tetraCB	6639	0.228	1513.692
2	DiCB	504	0.228	114.912

If assume uptake is from pore water, the BCF modeled range: 115 - 1534 ng/g ww

Recall, 2000 WSU observed Ct tissue levels at USGS (AS & SS exposures) of: 94.342 and 7434.862 ng/g wet wt.

AK5 041740

Appendix A2: ERA calculations for food chain:

Sediments > *Chironomus tentans*

Calculations based on June 2000 data

Assume the worst case scenario, thus use data from site with highest sediment contamination (Amanda)

Data from WSU database:

Sediment Total PCBs at Amanda 1999: 628.844 ng/g = 628.844 ug/kg = 0.629 ug/g

Sediment Total PCBs at Beaver Dam 1999: 409.160 ng/g = 409.160 ug/kg = 0.409 ug/g

Sediment Total PCBs at Confluence 1999: 10.822 ng/g = 10.822 ug/kg = 0.011 ug/g

Sediment Total PCBs at Amanda 2000: 198.168 ng/g = 198.168 ug/kg = 0.198 ug/g

Sediment Total PCBs at USGS Gauge 2000: 135.186 ng/g = 135.186 ug/kg = 0.135 ug/g

Surface Water Total PCBs at Amanda 1999: 0.035 ng/mL

Pore Water Total PCBs at Amanda 1999: 0.228 ng/mL = 0.228 ug/L

Surface Water Total PCBs at Amanda 2000: 0.019 ng/mL

Pore Water Total PCBs at Amanda 1999: 1.987 ng/mL = 1.987 ug/L

Amanda Sediment TOC = 4.26%

Estimate Concentration in midges

Use equations developed by Thomann, R. V. 1981. Equilibrium model of the fate of microcontaminants in diverse aquatic food chains. Can. J. Fish. Aquat. Sci. 38: 280-296.

Assume that uptake is from pore water and ingested sediment

A) Parameters obtained from the literature

Midge PCB uptake from water, k_u (mL/g/d) values from literature

Lydy, M.J. et al., Arch. Environ. Contam. Toxicol. 38:163-168, 2000.

Compound	Type	k_u value	mL/g/h	L/g/d
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AK5 041741

2-CB	- 1 SD	63.87	1.533
2-CB	mean	65.96	1.583
2-CB	+ 1 SD	68.05	1.633

Midge PCB elimination, k_e (1/d) values from literature

Lydy, M.J. et al., Arch. Environ. Contam. Toxicol. 38:163-168, 2000.

Compound	Type	k_e value	k_{ep} (elim parent; 1/d)	k_m (biotrans rate; 1/d)	k_e ($k_{ep}+k_m$; 1/d)
2-CB	- 1 SD		2.208	0.624	2.832
2-CB	mean		2.4	0.744	3.144
2-CB	+ 1 SD		2.592	0.864	3.456

Benthic organism chem. assimilation efficiency, CAE = $72 \pm 28.1\%$

from Morrison et al., Environ. Sci. Technol. 30:3377-3384, 1996

	%	frac
low end	43.90%	0.439
mean	72%	0.72
high end	100.10%	1

Benthic organism food assimilation efficiency, FAE

Organisms	% assimilated	frac assim.	citation
benthos	5.0%	0.05	Morrison et al., Environ. Sci. Technol. 30:3377-3384, 1996
benthos	20.0%	0.2	Thomann et al., Environ. Toxicol. Chem. 11:615-629, 1992
midge	11.9%	0.119	Rasmussen, J. B., Can. J. Zool. 62:1022-1026, 1984
midge	5.9%	0.059	Rasmussen, J. B., Can. J. Zool. 62:1022-1026, 1984

mean FAE = 10.700% 0.107

Midge ingestion rate, IR values

g food/g wet	
bw/d	citation
0.048	Liber, K. et al., Hydrobiologia 323:155-167, 1996
0.0505	Liber, K. et al., Hydrobiologia 323:155-167, 1996

AK5 041742

0.094 Sibley, P. K. et al., Environ. Toxicol. Chem. 16(2):336-345, 1997

mean IR value = 0.064166667

B) Calculation of Concentration in organism, Corg (midge), using parameters above

Original Thomann 1981 equation: $C_{org} = [(k_u \cdot C_w) + (CAE \cdot IR \cdot C_{food})] / k_e$; gives Corg for wet wt. of organism

Modified from Thomann (used below): $C_{org} = [(k_u \cdot C_w) + (CAE \cdot IR \cdot FAE \cdot C_{food})] / k_e$

use Cpw for Cw and Cs for Cfood

ku (L/g/d)	Cw (ug/L; pore water)	CAE (chem. assim. efficiency; unitless)	IR (ingest rate; g/g wet bw/d)	FAE (food assim. efficiency; unitless, frac. of ingestion)	Food PCB conc. (use Cs; ug/g)	ke (1/d)
1.583	1.987	0.720	0.064	0.107	0.198	3.144 calc with means
1.533	1.987	0.439	0.048	0.050	0.198	2.832 calc with lowest values
1.633	1.987	1.000	0.094	0.200	0.198	3.456 calc with highest values
Corg (ug/g) for midge = 1.001 using mean values for parameters						
1.08 using lowest values for parameters						
0.94 using highest values for parameters						

ku (L/g/d)	Cw (ug/L)	CAE (chem. assim. efficiency; unitless)	IR (ingest rate; g/g dry/d)	FAE (food assim. efficiency; unitless, frac. of ingestion)	Food PCB conc. (use Cs; ug/g)	ke (1/d)
1.633	1.987	0.720	0.064	0.107	0.198	2.832 highest uptake lowest elim; all others means
1.633	1.987	0.720	0.064	0.107	0.198	3.456 highest uptake highest elim; all others means
1.533	1.987	0.720	0.064	0.107	0.198	2.832 lowest uptake lowest elim; all others means

1.533 1.987 0.720 0.064 0.107 0.198 3.456 lowest uptake highest elim; all others means

Corg (ug/g) for midge = 1.146 *highest uptake lowest elim; all others means*
 0.939 *highest uptake highest elim; all others means*
 1.076 *lowest uptake lowest elim; all others means*
 0.882 *lowest uptake highest elim; all others means*

ku (L/g/d)	Cw (ug/L)	CAE (chem. assim. efficiency; unitless)	IR (ingest rate; g/g dry/d)	FAE (food assim. efficiency; unitless, frac. of ingestion)	Food PCB conc. (use Cs; ug/g)	ke (1/d)	
1.633	1.987	0.439	0.048	0.05	0.198	2.832	highest uptake lowest elim; all others lowest
1.633	1.987	0.439	0.048	0.05	0.198	3.456	highest uptake highest elim; all others lowest
1.533	1.987	0.439	0.048	0.05	0.198	2.832	lowest uptake lowest elim; all others lowest
1.533	1.987	0.439	0.048	0.05	0.198	3.456	lowest uptake highest elim; all others lowest
Corg (ug/g) for midge = 1.146			<i>highest uptake lowest elim; all others lowest</i>				
		0.939	<i>highest uptake highest elim; all others lowest</i>				
		1.076	<i>lowest uptake lowest elim; all others lowest</i>				
		0.881	<i>lowest uptake highest elim; all others lowest</i>				

ku (L/g/d)	Cw (ug/L)	CAE (chem. assim. efficiency; unitless)	IR (ingest rate; g/g dry/d)	FAE (food assim. efficiency; unitless, frac. of ingestion)	Food PCB conc. (use Cs; ug/g)	ke (1/d)	
1.633	1.987	1	0.094	0.2	0.198	2.832	highest uptake lowest elim; all others highest
1.633	1.987	1	0.094	0.2	0.198	3.456	highest uptake highest elim; all others highest
1.533	1.987	1	0.094	0.2	0.198	2.832	lowest uptake lowest elim; all others highest
1.533	1.987	1	0.094	0.2	0.198	3.456	lowest uptake highest elim; all others highest

AK5 041744

Corg (ug/g) for midge = 1.147	<i>highest uptake lowest elim; all others highest</i>
0.940	<i>highest uptake highest elim; all others highest</i>
1.077	<i>lowest uptake lowest elim; all others highest</i>
0.882	<i>lowest uptake highest elim; all others highest</i>

Range of values for Corg among all parameter combinations: 0.881 - 1.147 ug/g wet wt. OR 881 - 1147 ng/g wet wt.

Corg using mean parameter values: 1.001 ug/g wet wt. OR 1001 ng/g wet wt.

WSU observed *L. variegatus* tissue levels for total PCBs of 19,000 ng/g following an *in situ* exposure in the Landfill Tributary

WSU observed levels of total PCBs in indigenous oligochaetes at the same site of 8333 ng/g

2000 WSU observed Ct tissue levels at USGS (AS & SS exposures) of: 94.342 and 7434.862 ng/g wet wt.

Therefore, the calculations outlined above lie within the range of recent (year 2000) field measurements.

C) Estimate the Lv tissue conc. using literature BSAFs, BAF or BCF

where $BSAF = Corg/Csed = (ng/g \text{ lipid}) / (ng/g \text{ oc})$

BSAFs from the literature

(1) Oak Ridge, BJC/OR-112

(2) Bremle, G. and G. Ewald, Mar. Freshwater Res., 46:267-273, 1995.

$Csed, \text{ TOC-normalized} = (0.629 \text{ ug/g sed}) * (\text{g sed} / 0.0426 \text{ g oc}) = 14.76 \text{ ug/g oc}$

Citation	BSAF	Cs (ug/g oc)	Corg (ug/g lipid)	Corg (ng/g lipid)
1	9.016 total PCB	4.652	41.942	41942.432
1	37.193 total PCB	4.652	173.022	173021.836
2	0.114486293 total PCB	4.652	0.533	532.590
2	0.26303488 total PCB	4.652	1.224	1223.638
2	0.118185049 total PCB	4.652	0.550	549.797
2	0.422839033 total PCB	4.652	1.967	1967.047
2	0.449813396 total PCB	4.652	2.093	2092.532
2	2.406493506 total PCB	4.652	11.195	11195.008

AK5 041745

BAFs are lipid-based, $BAF = (C_{org}/C_{sed}) = (ug/g \text{ lipid})/(ug/g \text{ sed})$

from Bremle, G. and G. Ewald, Mar. Freshwater Res., 46:267-273, 1995.

BAF, lipid based	Cs (ug/g)	Corg (ug/g lipid)	Corg (ng/g lipid)
5.112038141 total PCB	0.198	1.012	1012.184
2.481343284 total PCB	0.198	0.491	491.306
2.077467722 total PCB	0.198	0.411	411.339
8.86602358 total PCB	0.198	1.755	1755.473
25.0273224 total PCB	0.198	4.955	4955.410
17.07834101 total PCB	0.198	3.382	3381.512

BSAF-based range from above: 532 - 173022 ng/g lipid

BAF-lipid-based range from above: 411 - 4955 ng/g lipid

WSU observed Ct tissue PCBs at USGS in 2000 that ranged from 3145 - 189665 ng/g lipid

BCFs for *Chironomus tentans* from the literature:

(1) Wood, L. W. et al., Water Res. 21:875-884, 1987

(2) Lydy, M.J. et al., Arch. Environ. Contam. Toxicol. 38:163-168, 2000.

Citation	congener	BCF	Cw (pore water; ug/L)	Corg (ug/kg = ng/g)
1	tetraCB	6639	1.987	13191.693
2	DiCB	504	1.987	1001.448

If assume uptake is from pore water, the BCF modeled range: 1001 - 13192 ng/g ww

Recall, 2000 WSU observed Ct tissue levels at USGS (AS & SS exposures) of: 94,342 and 7434.862 ng/g wet wt.

AK5 041746

Appendix A3: ERA calculations for food chain:

Sediments > Mayfly (e.g., *Hexagenia limbata*)

Calculations based on June 2000 data

Assume the worst case scenario, thus use data from site with highest sediment contamination (Amanda)

Data from WSU database:

Sediment Total PCBs at Amanda 1999: $628.844 \text{ ng/g} = 628.844 \text{ ug/kg} = 0.629 \text{ ug/g}$ Sediment Total PCBs at Beaver Dam 1999: $409.160 \text{ ng/g} = 409.160 \text{ ug/kg} = 0.409 \text{ ug/g}$ Sediment Total PCBs at Confluence 1999: $10.822 \text{ ng/g} = 10.822 \text{ ug/kg} = 0.011 \text{ ug/g}$ Sediment Total PCBs at Amanda 2000: $198.168 \text{ ng/g} = 198.168 \text{ ug/kg} = 0.198 \text{ ug/g}$ Sediment Total PCBs at USGS Gauge 2000: $135.186 \text{ ng/g} = 135.186 \text{ ug/kg} = 0.135 \text{ ug/g}$ Surface Water Total PCBs at Amanda 1999: 0.035 ng/mL Pore Water Total PCBs at Amanda 1999: $0.228 \text{ ng/mL} = 0.228 \text{ ug/L}$ Surface Water Total PCBs at Amanda 2000: 0.019 ng/mL Pore Water Total PCBs at Amanda 1999: $1.987 \text{ ng/mL} = 1.987 \text{ ug/L}$

Amanda Sediment TOC = 4.26%

Estimate Concentration in mayflies

A) Parameters obtained from the literature

Mayfly PCB uptake from sediment, k_s (g/g/h) values from literature

(1) Gobas et al., J. G. Lakes Res. 15(4):581-588, 1989.

(2) Drouillard, K. G. et al., J. Great Lakes Res. 22(1):26-35, 1996

Citation	Type	k_s value	g/g/h	g/g/d
1	PCBs		0.049	1.176
2	PCBs		0.125	3.000
2	PCBs		0.026	0.624
2	PCBs		0.024	0.576

AK5 041747

2	PCBs	0.195	4.680
	<i>mean</i>	<i>0.084</i>	<i>2.011</i>
	<i>stdev</i>	<i>0.074</i>	<i>1.788</i>

Mayfly PCB elimination, k_e (1/d) values from literature

Gobas et al., J. G. Lakes Res. 15(4):581-588, 1989.

Type	k_e value	k_e (1/h)	k_e (1/d)
PCB-101		0.014	0.336
PCB-87		0.013	0.312
PCB-118		0.014	0.336
PCB-153		0.009	0.216
PCB-138		0.008	0.192
PCB-180		0.008	0.192
	<i>mean</i>	<i>0.011</i>	<i>0.264</i>
	<i>stdev</i>	<i>0.003</i>	<i>0.071</i>

Benthic organism chem. assimilation efficiency, $CAE = 72 \pm 28.1\%$

from Morrison et al., Environ. Sci. Technol. 30:3377-3384, 1996

	%	frac
low end	43.90%	0.439
<i>mean</i>	<i>72%</i>	<i>0.72</i>
high end	100.10%	1

Benthic organism food assimilation efficiency, FAE

Organisms	% assimilated	frac assim.	citation
benthos	5.0%	0.05	Morrison et al., Environ. Sci. Technol. 30:3377-3384, 1996
benthos	20.0%	0.2	Thomann et al., Environ. Toxicol. Chem. 11:615-629, 1992
midge	11.9%	0.119	Rasmussen, J. B., Can. J. Zool. 62:1022-1026, 1984
midge	5.9%	0.059	Rasmussen, J. B., Can. J. Zool. 62:1022-1026, 1984
<i>mean FAE =</i>	<i>10.700%</i>	<i>0.107</i>	

Mayfly ingestion rate, IR values

AK5 041748

g food/g wet

bw/d citation

0.203 Dermott, R. Hydrobiologia 83:499-503, 1981

0.672 Dermott, R. Hydrobiologia 83:499-503, 1981

mean IR value = 0.4375

B) Calculation of Concentration in organism, Corg (midge), using parameters above

Assumption is that uptake from water is negligible and that ks corresponds to pore water and ingested sediment
see Gobas et al., J. G. Lakes Res. 15(4):581-588, 1989.

Modified from Thomann (used below): $C_{org} = (CAE \cdot IR \cdot FAE \cdot C_{food}) / k_e$ Simple toxicokinetics approach (used below): $C_{org} = (k_s \cdot C_w) / k_e$

use Cs for Cfood

ks (g sed/g/d)	CAE (chem. assim. efficiency; unitless)	IR (ingest rate; g/g wet bw/d)	FAE (food assim. efficiency; unitless, frac. of ingestion)	Food PCB conc. (use Cs; ug/g)	ke (1/d)
2.011	0.720	0.438	0.107	0.198	0.264 calc with means
0.576	0.439	0.203	0.050	0.198	0.192 calc with lowest values
4.680	1.000	0.672	0.200	0.198	0.336 calc with highest values
Corg (ug/g) for mayfly = 0.02528 using mean values for parameters and $C_{org} = (CAE \cdot IR \cdot FAE \cdot C_s) / k_e$					
	0.00460				using lowest values for parameters and $C_{org} = (CAE \cdot IR \cdot FAE \cdot C_s) / k_e$
	0.07920				using highest values for parameters and $C_{org} = (CAE \cdot IR \cdot FAE \cdot C_s) / k_e$
Corg (ug/g) for mayfly = 1.50840 using mean values for ks and ke and $C_{org} = (k_s C_s) / k_e$					
	0.59400				using mean lowest for ks and ke and $C_{org} = (k_s C_s) / k_e$
	2.75786				using highest values for ks and ke and $C_{org} = (k_s C_s) / k_e$

AK5 041749

ks (g sed/g/d)	CAE (chem. assim. efficiency; unitless)	IR (ingest rate; g/g dry/d)	FAE (food assim. efficiency; unitless, frac. of ingestion)	Food PCB conc. (use Cs; ug/g)	ke (1/d)	
4.680	0.720	0.438	0.107	0.198	0.192	highest uptake lowest elim; all others means
4.680	0.720	0.438	0.107	0.198	0.336	highest uptake highest elim; all others means
0.576	0.720	0.438	0.107	0.198	0.192	lowest uptake lowest elim; all others means
0.576	0.720	0.438	0.107	0.198	0.336	lowest uptake highest elim; all others means
<hr/>						
Corg (ug/g) for mayfly = 0.03476		<i>lowest elim; all others means and Corg = (CAE*IR*FAE*Cs)/ke</i>				
0.01986		<i>highest elim; all others means and Corg = (CAE*IR*FAE*Cs)/ke</i>				
<hr/>						
Corg (ug/g) for mayfly = 4.82625		<i>highest uptake lowest elim and Corg = (ks*Cs)/ke</i>				
2.75786		<i>highest uptake highest elim and Corg = (ks*Cs)/ke</i>				
0.59400		<i>lowest uptake lowest elim and Corg = (ks*Cs)/ke</i>				
0.33943		<i>lowest uptake highest elim and Corg = (ks*Cs)/ke</i>				

ks (g sed/g/d)	CAE (chem. assim. efficiency; unitless)	IR (ingest rate; g/g dry/d)	FAE (food assim. efficiency; unitless, frac. of ingestion)	Food PCB conc. (use Cs; ug/g)	ke (1/d)	
4.680	0.439	0.203	0.050	0.198	0.192	highest uptake lowest elim; all others lowest
4.680	0.439	0.203	0.050	0.198	0.336	highest uptake highest elim; all others lowest
0.576	0.439	0.203	0.050	0.198	0.192	lowest uptake lowest elim; all others lowest
0.576	0.439	0.203	0.050	0.198	0.336	lowest uptake highest elim; all others lowest
<hr/>						
Corg (ug/g) for mayfly = 0.00460		<i>lowest elim; all others lowest and Corg = (CAE*IR*FAE*Cs)/ke</i>				
0.00263		<i>highest elim; all others lowest and Corg = (CAE*IR*FAE*Cs)/ke</i>				

AK5 041750

ks (g sed/g/d)	CAE (chem. assim. efficiency; unitless)	IR (ingest rate; g/g dry/d)	FAE (food assim. efficiency; unitless, frac. of ingestion)	Food PCB conc. (use Cs; ug/g)	ke (1/d)	
4.680	1.000	0.672	0.200	0.198	0.192	highest uptake lowest elim; all others highest
4.680	1.000	0.672	0.200	0.198	0.336	highest uptake highest elim; all others highest
0.576	1.000	0.672	0.200	0.198	0.192	lowest uptake lowest elim; all others highest
0.576	1.000	0.672	0.200	0.198	0.336	lowest uptake highest elim; all others highest
Corg (ug/g) for mayfly = 0.13860		lowest elim; all others highest and Corg = (CAE*IR*FAE*Cs)/ke				
0.07920		highest elim; all others highest and Corg = (CAE*IR*FAE*Cs)/ke				

Range of values for Corg = (CAE*IR*FAE*Cs)/
Corg using mean parameter values:

0.0046 - 0.1386 ug/g wet wt. OR 4.6 - 138.6 ng/g wet wt.
0.0253 ug/g wet wt. OR 25.3 ng/g wet wt,

Range of values for Corg = (ks*Cs)/ke:
Corg using mean ks and ke values:

0.339 - 4.826 ug/g wet wt. OR 339 - 4826 ng/g wet wt.
1.508 ug/g wet wt. OR 1508 ng/g wet wt,

Values for field-collected mayflies in the literature:

ng/g wet	Citation
4.83 - 10.6	Gobas et al., J. G. Lakes Res. 15(4):581-588, 1989., data for 6 congeners
3.09 - 110.5	Corkum et al., J. Great Lakes Res. 23(4):383-390, 1997., data for 4 congeners
94 - 140	Baron, L. A., Environ. Toxicol. Chem. 18(4):621-627, 1999, data for Aroclor 1254
274.6	Drouillard, K. G. et al., J. Great Lakes Res. 22(1):26-35, 1996.
315.1	Drouillard, K. G. et al., J. Great Lakes Res. 22(1):26-35, 1996.

The calculations outlined above lie within the range of published field measurements.
However, the simple toxicokinetic approach tends to overestimate by up to a factor of 10-12

If using the 1999 Amanda sediment concentration of 629 ng/g total PCBs, the estimates above would increase by a factor of:
(0.629 ug/g)/(0.198 ug/g) = 3.177

Range of values for Corg using 1999 sediment data for Amanda = (CAE*IR*FAE*Cs)/ke:
Corg using mean parameter values:

14.61 - 440.33 ng/g wet w
80.38 ng/g wet wt,

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Range of values for Corg using 1999 sediment data for Amanda = $(k_s \cdot C_s)/k_e$:

1077 - 15332 ng/g wet wt.

Corg using mean k_s and k_e values:

4791 ng/g wet wt.

Therefore, the ingestion-based model ($C_{org} = (CAE \cdot IR \cdot FAE \cdot C_s)/k_e$) gives the best estimates of mayfly tissue conc.

C) Estimate the mayfly tissue conc. using literature BSAFs or BAF

where $BSAF = C_{org}/C_{sed} = (\text{ng/g lipid})/(\text{ng/g oc})$

BSAFs from the literature

(1) Oak Ridge, BJC/OR-112; general for invertebrates

(2) Drouillard, K. G. et al., J. Great Lakes Res. 22(1):26-35, 1996

$C_{sed, \text{ TOC-normalized}} = (0.629 \text{ ug/g sed}) \cdot (\text{g sed}/0.0426 \text{ g oc}) = 14.76 \text{ ug/g oc}$

Citation	BSAF	Compound	2000 C_s (ug/g oc)	Corg (ug/g lipid)	Corg (ng/g lipid)
1	9.016	tot PCB	4.652	41.942	41942.432
1	37.193	tot PCB	4.652	173.022	173021.836
2	1.78	PCB28	4.652	8.281	8280.560
2	5.09	PCB52	4.652	23.679	23678.680
2	6.45	PCB99	4.652	30.005	30005.400
2	4.72	PCB66	4.652	21.957	21957.440
2	7.43	PCB101	4.652	34.564	34564.360
2	6	PCB87	4.652	27.912	27912.000
2	5.54	PCB110	4.652	25.772	25772.080
2	5.62	PCB118	4.652	26.144	26144.240
2	7.39	PCB138	4.652	34.378	34378.280
2	8.95	PCB153	4.652	41.635	41635.400
2	9.22	PCB170	4.652	42.891	42891.440
2	8.42	PCB180	4.652	39.170	39169.840
2	7.5	PCB182	4.652	34.890	34890.000
2	4.86	PCB28	4.652	22.609	22608.720
2	4.76	PCB52	4.652	22.144	22143.520
2	6.01	PCB99	4.652	27.959	27958.520
2	4.13	PCB66	4.652	19.213	19212.760
2	5.93	PCB101	4.652	27.586	27586.360

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2	5.22	PCB87	4.652	24.283	24283.440
2	4.53	PCB110	4.652	21.074	21073.560
2	5.31	PCB118	4.652	24.702	24702.120
2	5.53	PCB138	4.652	25.726	25725.560
2	6.5	PCB153	4.652	30.238	30238.000
2	5.14	PCB170	4.652	23.911	23911.280
2	5.07	PCB180	4.652	23.586	23585.640
2	4.78	PCB182	4.652	22.237	22236.560

mean from Drouillard et al., BSAFs 27174.837

stdev from Drouillard et al., BSAFs 7471.241679

Lipid-normalized tissue conc from field collected mayflies, literature values:

218.9 - 4172 ng/g lipid summed PCB congeners 101, 138, 153, 180 (Corkum et al., J. Great Lakes Res. 23(4):383-390, 19

12356.4 - 16057.3 ng/g lipid (Drouillard, K. G. et al., J. Great Lakes Res. 22(1):26-35, 1996.)

Therefore, using the Hexagenia-specific BSAFs to estimate mean mayfly tissue PCBs for Dicks Creek tends to overestimate the tissue burden reported in the literature by a factor ranging from 1.69 - 124 (i.e., up to 2 orders of magnitude)

BAFs for mayflies, where $BAF = (Corg/Csed) = (ug/g \text{ wet})/(ug/g \text{ dry})$

(1) Baron, L. A. et al., Environ. Toxicol. Chem 18(4):621-627, 1999

(2) Gobas et al., J. G. Lakes Res. 15(4):581-588, 1989., data for 6 congeners

Citation	BAF, lipid based	Using June 2000 Amanda sediment data			Using 1999 Amanda sediment	
		Cs (ug/g)	Corg (ug/g wet)	Corg (ng/g wet)	Cs (ug/g)	Corg (ug/g wet)
1	0.046561 Aroclor 1254	0.198	0.009	9.219 low	0.629	0.029
1	0.354266 Aroclor 1254	0.198	0.070	70.145	0.629	0.223
1	0.661971 Aroclor 1254	0.198	0.131	131.070	0.629	0.416
2	0.19 PCB101	0.198	0.038	37.620	0.629	0.120
2	0.46 PCB101	0.198	0.091	91.080	0.629	0.289
2	0.73 PCB101	0.198	0.145	144.540	0.629	0.459
2	0.2 PCB87	0.198	0.040	39.600	0.629	0.126
2	0.54 PCB87	0.198	0.107	106.920	0.629	0.340
2	0.88 PCB87	0.198	0.174	174.240	0.629	0.554
2	0.14 PCB118	0.198	0.028	27.720	0.629	0.088
2	0.41 PCB118	0.198	0.081	81.180	0.629	0.258
2	0.68 PCB118	0.198	0.135	134.640	0.629	0.428

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2	0.2 PCB153	0.198	0.040	39.600	0.629	0.126
2	0.71 PCB153	0.198	0.141	140.580	0.629	0.447
2	1.22 PCB153	0.198	0.242	241.560	0.629	0.767
2	0.25 PCB138	0.198	0.050	49.500	0.629	0.157
2	0.54 PCB138	0.198	0.107	106.920	0.629	0.340
2	0.83 PCB138	0.198	0.164	164.340	0.629	0.522
2	0.62 PCB180	0.198	0.123	122.760	0.629	0.390
2	1.27 PCB180	0.198	0.251	251.460 high	0.629	0.799

Using the 2000 WSU Amanda sediment data for PCBs, the BAF-derived estimates of mayfly tissue residues would range from 9.219 - 251.5

Using the 1999 WSU Amanda sediment data for PCBs, the BAF-derived estimates of mayfly tissue residues would range from 29.29 - 799 ng

Compare these BAF-derived estimates to published values for field-collected mayflies:

ng/g wet	Citation
4.83 - 10.6	Gobas et al., J. G. Lakes Res. 15(4):581-588, 1989., data for 6 congeners
3.09 - 110.5	Corkum et al., J. Great Lakes Res. 23(4):383-390, 1997., data for 4 congeners
94 - 140	Baron, L. A., Environ. Toxicol. Chem. 18(4):621-627, 1999, data for Aroclor 1254
274.6, 315.1	Drouillard, K. G. et al., J. Great Lakes Res. 22(1):26-35, 1996.

BAF-derived estimates of tissue burdens for emergent mayflies in Dicks Creek are in very close agreement with literature values. This is especially true for the June 2000 Amanda sediment-based predictions

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Appendix A3: ERA calculations for food chain:

Sediments > Mayfly (e.g., *Hexagenia limbata*)

Calculations based on June 2000 data

Assume the worst case scenario, thus use data from site with highest sediment contamination (Amanda)

Data from WSU database:

Sediment Total PCBs at Amanda 1999: 628.844 ng/g = 628.844 ug/kg = 0.629 ug/g

Sediment Total PCBs at Beaver Dam 1999: 409.160 ng/g = 409.160 ug/kg = 0.409 ug/g

Sediment Total PCBs at Confluence 1999: 10.822 ng/g = 10.822 ug/kg = 0.011 ug/g

Sediment Total PCBs at Amanda 2000: 198.168 ng/g = 198.168 ug/kg = 0.198 ug/g

Sediment Total PCBs at USGS Gauge 2000: 135.186 ng/g = 135.186 ug/kg = 0.135 ug/g

Surface Water Total PCBs at Amanda 1999: 0.035 ng/mL

Pore Water Total PCBs at Amanda 1999: 0.228 ng/mL = 0.228 ug/L

Surface Water Total PCBs at Amanda 2000: 0.019 ng/mL

Pore Water Total PCBs at Amanda 1999: 1.987 ng/mL = 1.987 ug/L

Amanda Sediment TOC = 4.26%

Estimate Concentration in mayflies

A) Parameters obtained from the literature

Mayfly PCB uptake from sediment, k_s (g/g/h) values from literature

(1) Gobas et al., J. G. Lakes Res. 15(4):581-588, 1989.

(2) Drouillard, K. G. et al., J. Great Lakes Res. 22(1):26-35, 1996

Citation	Type k_s value	g/g/h	g/g/d
1	PCBs	0.049	1.176
2	PCBs	0.125	3.000
2	PCBs	0.026	0.624
2	PCBs	0.024	0.576

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2	PCBs	0.195	4.680
	<i>mean</i>	<i>0.084</i>	<i>2.011</i>
	<i>stdev</i>	<i>0.074</i>	<i>1.788</i>

Mayfly PCB elimination, k_e (1/d) values from literature

Gobas et al., J. G. Lakes Res. 15(4):581-588, 1989.

Type k_e value	k_e (1/h)	k_e (1/d)
PCB-101	0.014	0.336
PCB-87	0.013	0.312
PCB-118	0.014	0.336
PCB-153	0.009	0.216
PCB-138	0.008	0.192
PCB-180	0.008	0.192
<i>mean</i>	<i>0.011</i>	<i>0.264</i>
<i>stdev</i>	<i>0.003</i>	<i>0.071</i>

Benthic organism chem. assimilation efficiency, CAE = $72 \pm 28.1\%$

from Morrison et al., Environ. Sci. Technol. 30:3377-3384, 1996

	%	frac
low end	43.90%	0.439
<i>mean</i>	<i>72%</i>	<i>0.72</i>
high end	100.10%	1

Benthic organism food assimilation efficiency, FAE

Organisms	% assimilated	frac assim.	citation
benthos	5.0%	0.05	Morrison et al., Environ. Sci. Technol. 30:3377-3384, 1996
benthos	20.0%	0.2	Thomann et al., Environ. Toxicol. Chem. 11:615-629, 1992
midge	11.9%	0.119	Rasmussen, J. B., Can. J. Zool. 62:1022-1026, 1984
midge	5.9%	0.059	Rasmussen, J. B., Can. J. Zool. 62:1022-1026, 1984

mean FAE = 10.700% 0.107

Mayfly ingestion rate, IR values

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g food/g wet

bw/d citation

0.203 Dermott, R. Hydrobiologia 83:499-503, 1981

0.672 Dermott, R. Hydrobiologia 83:499-503, 1981

mean IR value = 0.4375

B) Calculation of Concentration in organism, Corg (midge), using parameters above

Assumption is that uptake from water is negligible and that ks corresponds to pore water and ingested sediment
see Gobas et al., J. G. Lakes Res. 15(4):581-588, 1989.

Modified from Thomann (used below): $C_{org} = (CAE \cdot IR \cdot FAE \cdot C_{food}) / k_e$ Simple toxicokinetics approach (used below): $C_{org} = (k_s \cdot C_w) / k_e$

use Cs for Cfood

ks (g sed/g/d)	CAE (chem. assim. efficiency; unitless)	IR (ingest rate; g/g wet bw/d)	FAE (food assim. efficiency; unitless, frac. of ingestion)	Food PCB conc. (use Cs; ug/g)	ke (1/d)
2.011	0.720	0.438	0.107	0.198	0.264 calc with means
0.576	0.439	0.203	0.050	0.198	0.192 calc with lowest values
4.680	1.000	0.672	0.200	0.198	0.336 calc with highest values
<hr/>					
Corg (ug/g) for mayfly = 0.02528			using mean values for parameters and $C_{org} = (CAE \cdot IR \cdot FAE \cdot C_s) / k_e$		
0.00460			using lowest values for parameters and $C_{org} = (CAE \cdot IR \cdot FAE \cdot C_s) / k_e$		
0.07920			using highest values for parameters and $C_{org} = (CAE \cdot IR \cdot FAE \cdot C_s) / k_e$		
<hr/>					
Corg (ug/g) for mayfly = 1.50840			using mean values for ks and ke and $C_{org} = (k_s C_s) / k_e$		
0.59400			using mean lowest for ks and ke and $C_{org} = (k_s C_s) / k_e$		
2.75786			using highest values for ks and ke and $C_{org} = (k_s C_s) / k_e$		

ks (g sed/g/d)	CAE (chem. assim. efficiency; unitless)	IR (ingest rate; g/g dry/d)	FAE (food assim. efficiency; unitless, frac. of ingestion)	Food PCB conc. (use Cs; ug/g)	ke (1/d)	
4.680	0.720	0.438	0.107	0.198	0.192	highest uptake lowest elim; all others means
4.680	0.720	0.438	0.107	0.198	0.336	highest uptake highest elim; all others means
0.576	0.720	0.438	0.107	0.198	0.192	lowest uptake lowest elim; all others means
0.576	0.720	0.438	0.107	0.198	0.336	lowest uptake highest elim; all others means
Corg (ug/g) for mayfly = 0.03476 <i>lowest elim; all others means and Corg = (CAE*IR*FAE*Cs)/ke</i>						
0.01986 <i>highest elim; all others means and Corg = (CAE*IR*FAE*Cs)/ke</i>						
Corg (ug/g) for mayfly = 4.82625 <i>highest uptake lowest elim and Corg = (ks*Cs)/ke</i>						
2.75786 <i>highest uptake highest elim and Corg = (ks*Cs)/ke</i>						
0.59400 <i>lowest uptake lowest elim and Corg = (ks*Cs)/ke</i>						
0.33943 <i>lowest uptake highest elim and Corg = (ks*Cs)/ke</i>						

ks (g sed/g/d)	CAE (chem. assim. efficiency; unitless)	IR (ingest rate; g/g dry/d)	FAE (food assim. efficiency; unitless, frac. of ingestion)	Food PCB conc. (use Cs; ug/g)	ke (1/d)	
4.680	0.439	0.203	0.050	0.198	0.192	highest uptake lowest elim; all others lowest
4.680	0.439	0.203	0.050	0.198	0.336	highest uptake highest elim; all others lowest
0.576	0.439	0.203	0.050	0.198	0.192	lowest uptake lowest elim; all others lowest
0.576	0.439	0.203	0.050	0.198	0.336	lowest uptake highest elim; all others lowest
Corg (ug/g) for mayfly = 0.00460 <i>lowest elim; all others lowest and Corg = (CAE*IR*FAE*Cs)/ke</i>						
0.00263 <i>highest elim; all others lowest and Corg = (CAE*IR*FAE*Cs)/ke</i>						

ks (g sed/g/d)	CAE (chem. assim. efficiency; unitless)	IR (ingest rate; g/g dry/d)	FAE (food assim. efficiency; unitless, frac. of ingestion)	Food PCB conc. (use Cs; ug/g)	ke (1/d)	
4.680	1.000	0.672	0.200	0.198	0.192	highest uptake lowest elim; all others highest
4.680	1.000	0.672	0.200	0.198	0.336	highest uptake highest elim; all others highest
0.576	1.000	0.672	0.200	0.198	0.192	lowest uptake lowest elim; all others highest
0.576	1.000	0.672	0.200	0.198	0.336	lowest uptake highest elim; all others highest
Corg (ug/g) for mayfly = 0.13860		lowest elim; all others highest and $Corg = (CAE \cdot IR \cdot FAE \cdot Cs) / ke$				
0.07920		highest elim; all others highest and $Corg = (CAE \cdot IR \cdot FAE \cdot Cs) / ke$				

Range of values for $Corg = (CAE \cdot IR \cdot FAE \cdot Cs) / ke$: 0.0046 - 0.1386 ug/g wet wt. OR 4.6 - 138.6 ng/g wet wt.
 Corg using mean parameter values: 0.0253 ug/g wet wt. OR 25.3 ng/g wet wt,

Range of values for $Corg = (ks \cdot Cs) / ke$: 0.339 - 4.826 ug/g wet wt. OR 339 - 4826 ng/g wet wt.
 Corg using mean ks and ke values: 1.508 ug/g wet wt. OR 1508 ng/g wet wt,

Values for field-collected mayflies in the literature:

ng/g wet	Citation
4.83 - 10.6	Gobas et al., J. G. Lakes Res. 15(4):581-588, 1989., data for 6 congeners
3.09 - 110.5	Corkum et al., J. Great Lakes Res. 23(4):383-390, 1997., data for 4 congeners
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The calculations outlined above lie within the range of published field measurements.
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If using the 1999 Amanda sediment concentration of 629 ng/g total PCBs, the estimates above would increase by a factor of:
 $(0.629 \text{ ug/g}) / (0.198 \text{ ug/g}) = 3.177$

Range of values for Corg using 1999 sediment data for Amanda = $(CAE \cdot IR \cdot FAE \cdot Cs) / ke$: 14.61 - 440.33 ng/g wet wt.
 Corg using mean parameter values: 80.38 ng/g wet wt,

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Range of values for Corg using 1999 sediment data for Amanda = $(k_s \cdot C_s)/k_e$:
Corg using mean k_s and k_e values:

1077 - 15332 ng/g wet wt.
4791 ng/g wet wt.

Therefore, the ingestion-based model ($C_{org} = (CAE \cdot IR \cdot FAE \cdot C_s)/k_e$) gives the best estimates of mayfly tissue conc.

C) Estimate the mayfly tissue conc. using literature BSAFs or BAF

where $BSAF = C_{org}/C_{sed} = (ng/g \text{ lipid})/(ng/g \text{ oc})$

BSAFs from the literature

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$C_{sed, \text{ TOC-normalized}} = (0.629 \text{ ug/g sed}) \cdot (g \text{ sed}/0.0426 \text{ g oc}) = 14.76 \text{ ug/g oc}$

Citation	BSAF	Compound	2000 C_s (ug/g oc)	Corg (ug/g lipid)	Corg (ng/g lipid)
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2	6.01	PCB99	4.652	27.959	27958.520
2	4.13	PCB66	4.652	19.213	19212.760
2	5.93	PCB101	4.652	27.586	27586.360

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2	5.22	PCB87	4.652	24.283	24283.440
2	4.53	PCB110	4.652	21.074	21073.560
2	5.31	PCB118	4.652	24.702	24702.120
2	5.53	PCB138	4.652	25.726	25725.560
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12356.4 - 16057.3 ng/g lipid (Drouillard, K. G. et al., J. Great Lakes Res. 22(1):26-35, 1996.)

Therefore, using the Hexagenia-specific BSAFs to estimate mean mayfly tissue PCBs for Dicks Creek tends to overestimate the tissue burdens reported in the literature by a factor ranging from 1.69 - 124 (i.e., up to 2 orders of magnitude)

BAFs for mayflies, where $BAF = (Corg/Csed) = (ug/g\ wet)/(ug/g\ dry)$

(1) Baron, L. A. et al., Environ. Toxicol. Chem 18(4):621-627, 1999

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Citation	BAF, lipid based	Using June 2000 Amanda sediment data			Using 1999 Amanda sediment data		
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2	0.46 PCB101	0.198	0.091	91.080	0.629	0.289	289.340
2	0.73 PCB101	0.198	0.145	144.540	0.629	0.459	459.170
2	0.2 PCB87	0.198	0.040	39.600	0.629	0.126	125.800
2	0.54 PCB87	0.198	0.107	106.920	0.629	0.340	339.660
2	0.88 PCB87	0.198	0.174	174.240	0.629	0.554	553.520
2	0.14 PCB118	0.198	0.028	27.720	0.629	0.088	88.060
2	0.41 PCB118	0.198	0.081	81.180	0.629	0.258	257.890
2	0.68 PCB118	0.198	0.135	134.640	0.629	0.428	427.720

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2	0.2 PCB153	0.198	0.040	39.600	0.629	0.126	125.800
2	0.71 PCB153	0.198	0.141	140.580	0.629	0.447	446.590
2	1.22 PCB153	0.198	0.242	241.560	0.629	0.767	767.380
2	0.25 PCB138	0.198	0.050	49.500	0.629	0.157	157.250
2	0.54 PCB138	0.198	0.107	106.920	0.629	0.340	339.660
2	0.83 PCB138	0.198	0.164	164.340	0.629	0.522	522.070
2	0.62 PCB180	0.198	0.123	122.760	0.629	0.390	389.980
2	1.27 PCB180	0.198	0.251	251.460 high	0.629	0.799	798.830

Using the 2000 WSU Amanda sediment data for PCBs, the BAF-derived estimates of mayfly tissue residues would range from 9.219 - 251.5 ng/g wet
Using the 1999 WSU Amanda sediment data for PCBs, the BAF-derived estimates of mayfly tissue residues would range from 29.29 - 799 ng/g wet

Compare these BAF-derived estimates to published values for field-collected mayflies:

ng/g wet	Citation
4.83 - 10.6	Gobas et al., J. G. Lakes Res. 15(4):581-588, 1989., data for 6 congeners
3.09 - 110.5	Corkum et al., J. Great Lakes Res. 23(4):383-390, 1997., data for 4 congeners
94 - 140	Baron, L. A., Environ. Toxicol. Chem. 18(4):621-627, 1999, data for Aroclor 1254
274.6, 315.1	Drouillard, K. G. et al., J. Great Lakes Res. 22(1):26-35, 1996.

BAF-derived estimates of tissue burdens for emergent mayflies in Dicks Creek are in very close agreement with literature values. This is especially true for the June 2000 Amanda sediment-based predictions

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Appendix A4: Uptake of PCBs to catfish will be modeled using the following routes
 uptake from contaminated invertebrate food sources to catfish
 uptake of ingested contaminated sediments to catfish

1a. OEPA fish data from Dicks Creek (demersal species only)

Year	Species	Total PCBs (ug/kg)	Total PCBs (ug/kg lipid) using mean lipid data from lit
1996	Channel Cat	620	18235.29
1998	Channel Cat	307	9029.41
1996	Carp	220	4059.04
1998	Carp	26500	488929.89
1998	Carp	1860	34317.34
1998	White Sucker	4190	64461.54
1998	White Sucker	1820	28000.00
Mean Channel Cat		463.50	13632.35
Stdev Channel Cat		221.32	6509.54
Mean Carp		9526.67	175768.76
Stdev Carp		14722.19	271627.16
Mean White Sucker		3005.00	46230.77
Stdev White Sucker		1675.84	25782.20
Mean Overall		5073.86	92433.22
Stdev Overall		9547.22	175970.00

1b. Lipid levels of demersal fish:

Species	frac lipid	Citation
channel cat	0.0260	Gale et al., Environ. Sci. Technol. 31(1):178-187, 1997
channel cat	0.0380	Gale et al., Environ. Sci. Technol. 31(1):178-187, 1997
channel cat	0.0390	Gale et al., Environ. Sci. Technol. 31(1):178-187, 1997
channel cat	0.0300	Gale et al., Environ. Sci. Technol. 31(1):178-187, 1997
channel cat	0.0370	Gale et al., Environ. Sci. Technol. 31(1):178-187, 1997
<i>C. carpio</i>	0.0840	Gerstenberger, S. L. et al., Environ. Toxicol. Chem. 16(11):2222-2228, 1997
<i>C. carpio</i>	0.0387	Hajslovia, J. et al., Environ. Contam. Toxicol. 59:452-459, 1997
<i>C. carpio</i>	0.0399	Hajslovia, J. et al., Environ. Contam. Toxicol. 59:452-459, 1997
white sucker	0.0800	Morrison et al., Environ. Sci. Technol. 31(11):3267-3273, 1997
white sucker	0.0500	Morrison et al., Environ. Sci. Technol. 31(11):3267-3273, 1997
stdev channel cat	0.0340	
mean channel cat	0.0057	
mean carp	0.0542	
stdev carp	0.0258	
mean white sucker	0.0650	
stdev white sucker	0.0212	

2. Catfish dietary constituent data:

from Hill, T. D. et al., J. Freshwat. Ecol. 10(4):319-323.

these values are for a <30 cm fish as these would be most likely consumed by avian and mammalian predators

Taxon	Common name	Proportion
Ephemeropterans	Mayflies	0.246
Trichopterans	Caddis flies	0.161
Chironomidae	midge	0.135
adult Dipterans	midge	0.038
other aquatic inverts	invertebrates	0.182
Coleopterans	beetles	0.073
Terrestrial insects	insects	0.068
Formicidae		0.031

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Bufo	0.068
all aquatic inverts	0.762
all others	0.240
total all above	1.002

Therefore, aquatic invertebrate species comprise 76.2% of dietary taxa

Sediments in fish gut data:

from Morrison et al., Environ. Sci. Technol. 31(11):3267-3273, 1997

Species	Proportion
White Sucker	10
White Sucker	5
Freshwater drum	5
gizzard shad	10

Assume that catfish ingest 10% sediment in gut

Diet assumptions: 10% of total diet is sediments, therefore 90% represents the taxa proportions above.

Then of the 90% of total diet, 76.2% of that are aquatic invertebrates. Therefore,

of every 100 g eaten, 10 g sediment, 90 g animal+aquatic invertebrate

$0.762 \times 90\text{g} = 68.58\text{ g}$

So aquatic invertebrates comprise 68.58% of total diet (frac = 0.6858)

For each aquatic invertebrate taxon of interest, this is the breakdown

Animal/invert diet (g)	Taxon	Common Name	Proportion taxon in gut	fraction in total diet
90	Ephemeropteran	Mayflies	0.246	0.2214
90	Trichopterans	Caddis flies	0.161	0.1449
90	Chironomidae	midge	0.135	0.1215
90	adult Dipterans	midge	0.038	0.0342
90	other aquatic inv	invertebrates	0.182	0.1638
0				
		Totals=	0.762	0.6858 it checks!!

3. Fish PCB uptake rate constants (k_u) values from literature for various species

from Sijm, D. T. H. M. and van der Linde, A., Environ. Sci. Technol. 29(11):2769-2777, 1995

k_u (L/g/d)	mean k_u (L/kg/d) =	3.5078
5.9	stdev k_u (L/kg/d) =	4.576361719
18		
4.7		
3.8		
1.5		
1.8		

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11
5.9
6.3
1.1
3.4
0.588
0.288
0.323
0.7762
0.605
0.288
0.251
0.129

4. Fish PCB elimination, k_e (1/d) values for various species from literature

k_e (1/h)	k_e (1/d)	
0.004	0.0960	from Leblanc, G. A., Environ. Sci. Technol. 29(10):154-160, 1995
	0.0210	Sijm, D. T. H. M., Environ. Sci. Technol. 26(11):2162-2174, 1992
	0.0030	Sijm, D. T. H. M., Environ. Sci. Technol. 26(11):2162-2174, 1992
	0.006	Sijm, D. T. H. M., Environ. Sci. Technol. 26(11):2162-2174, 1992
	0.008	Sijm, D. T. H. M., Environ. Sci. Technol. 26(11):2162-2174, 1992
	0.011	Sijm, D. T. H. M., Environ. Sci. Technol. 26(11):2162-2174, 1992
	0.2	Sijm, D. T. H. M. and van der Linde, A., Environ. Sci. Technol. 29(11):2769-2777, 1995
	0.25	Sijm, D. T. H. M. and van der Linde, A., Environ. Sci. Technol. 29(11):2769-2777, 1995
	0.01	Sijm, D. T. H. M. and van der Linde, A., Environ. Sci. Technol. 29(11):2769-2777, 1995
	0.01	Sijm, D. T. H. M. and van der Linde, A., Environ. Sci. Technol. 29(11):2769-2777, 1995
	0.03	Sijm, D. T. H. M. and van der Linde, A., Environ. Sci. Technol. 29(11):2769-2777, 1995
	0.03	Sijm, D. T. H. M. and van der Linde, A., Environ. Sci. Technol. 29(11):2769-2777, 1995
	0.01	Sijm, D. T. H. M. and van der Linde, A., Environ. Sci. Technol. 29(11):2769-2777, 1995
	0.01	Sijm, D. T. H. M. and van der Linde, A., Environ. Sci. Technol. 29(11):2769-2777, 1995
	0.01	Sijm, D. T. H. M. and van der Linde, A., Environ. Sci. Technol. 29(11):2769-2777, 1995
	0.05	Sijm, D. T. H. M. and van der Linde, A., Environ. Sci. Technol. 29(11):2769-2777, 1995
	0.01	Sijm, D. T. H. M. and van der Linde, A., Environ. Sci. Technol. 29(11):2769-2777, 1995
mean =	0.0450	
stdev =	0.0720	

5. Fish chem. assimilation efficiency, CAE =

72 ± 28.1%	Morrison et al., Environ. Sci. Technol. 30:3377-3384, 1996
33%	into fish (spot; bottom feeder) from PREY: DiPinto, L. M., Environ. Toxicol. Chem. 16(12):2568-2575, 1997.
75%	Morrison et al., Environ. Sci. Technol. 30:3377-3384, 1996
70%	alewife, Thomann, R. V. and Connolly, J. P., Environ. Sci. Technol. 18(2):65-71, 1984
80%	lake trout, Thomann, R. V. and Connolly, J. P., Environ. Sci. Technol. 18(2):65-71, 1984

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50%	lake trout, Jackson, L. J. and Scindler, D. E., Environ. Sci. Technol. 30(6):1861-1865, 1996.
47%	tetraCB, Gobas, F. A. P. C., Environ. Toxicol. Chem. 12:567-576, 1993
42%	hexaCB, Gobas, F. A. P. C., Environ. Toxicol. Chem. 12:567-576, 1993
53%	OctaCB, Gobas, F. A. P. C., Environ. Toxicol. Chem. 12:567-576, 1993
34%	DecaCB, Gobas, F. A. P. C., Environ. Toxicol. Chem. 12:567-576, 1993
<i>mean</i>	54% excluding Morrison et al., 1996 value
<i>stdev</i>	17% excluding Morrison et al., 1996 value

6. Demersal fish food assimilation efficiency, FAE

FAE	species	
0.43	Bighead carp	Opuszynski, K. et al., Hydrobiologia 220(1):49-56, 1991
0.13	Bighead carp	Opuszynski, K. et al., Hydrobiologia 220(1):49-56, 1991
0.30	mummichog	Iannuzzi, T. J., Environ. Toxicol. Chem. 15(11):1979-1992, 1996
0.70	mummichog	Iannuzzi, T. J., Environ. Toxicol. Chem. 15(11):1979-1992, 1996
<i>mean</i>	0.39	
<i>stdev</i>	0.24	

7. Channel catfish ingestion rate:

from Vigg, S. et al., Trans. Amer. Fish. Soc. 120(4):421-438, 1991

	kg/kg wet bw/d
	0.0126
	0.0171
	0.058
<i>mean</i>	0.02923
<i>stdev</i>	0.02501

8. Data from WSU database:

Sediment Total PCBs at Amanda 1999: 628.844 ng/g = 628.844 ug/kg = 0.629 ug/g
 Sediment Total PCBs at Beaver Dam 1999: 409.160 ng/g = 409.160 ug/kg = 0.409 ug/g
 Sediment Total PCBs at Confluence 1999: 10.822 ng/g = 10.822 ug/kg = 0.011 ug/g

Sediment Total PCBs at Amanda 2000: 198.168 ng/g = 198.168 ug/kg = 0.198 ug/g
 Sediment Total PCBs at USGS Gauge 2000: 135.186 ng/g = 135.186 ug/kg = 0.135 ug/g

Surface Water Total PCBs at Amanda 1999: 0.035 ng/mL = 0.035 ug/L
 Surface Water Total PCBs at Amanda 2000: 0.019 ng/mL = 0.019 ug/L
 Surface Water Total PCBs at USGS 2000: 0.026 ng/mL = 0.026 ug/L

Amanda Sediment TOC = 4.26%
 USGS Sediment TOC = 3.89%

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9. Contamination for each food item in catfish/white sucker diet, from (2.) above:

Common Name	Proportion taxon in gut
Mayflies	0.2214
Caddis flies	0.1449
midge	0.1215
midge	0.0342
invertebrates	0.1638
sediment	0.1

From this list of species and proportions in gut from above, we make the following assumptions:

Caddis flies will represent mayflies therefore we add their proportions together: 0.3663

The total midge proportion is the sum of 0.0135 + 0.038 = 0.1557

Oligochaete data will be used for "invertebrates"

Common Name	Proportion taxon in gut	1999 WSU Mean conc. (ug/g)	2000 WSU Mean conc. (ug/g)	Literature high (ug/g)	Literature low modeled conc (ug/g)	modeled conc high (ug/g)	modeled conc low (ug/g)
Mayflies	0.3663	NA	NA	0.3151	0.00309	0.44033	0.0046
midge	0.1557	NA	3.7646	NA	NA	1.147	0.101
oligochaetes	0.1638	0.14225	0.4695875	NA	NA	3301.403	0.008
sediments	0.1	0.629	0.198	NA	NA	NA	NA

Below is the concentration of each food item based on its proportion of the catfish/white sucker diet and then the sum of all food concentrations for a total dietary contaminant level

Common Name	1999 WSU Mean conc. (ug/g)	2000 WSU Mean conc. (ug/g)	Literature high (ug/g)	Literature low modeled conc (ug/g)	modeled conc high (ug/g)	modeled conc low (ug/g)
Mayflies			0.11542113	0.001131867	0.161292879	0.00168498
midge		0.58614822			0.1785879	0.0157257
oligochaetes	0.02330055	0.076918433			540.7698114	0.0013104
sediments	0.0629	0.0198				

Totals food PCB conc. (ug/g) for various combinations of above data

Total food PCBs (ug/g)

1999 WSU sed, oligochaete, 2000 WSU midge, literature high mayfly:	0.7878	
1999 WSU sed, oligochaete, 2000 WSU midge, literature low mayfly:	1.2596	high from data
1999 WSU sed, oligochaete, 2000 WSU midge, model high mayfly:	0.3244	
1999 WSU sed, oligochaete, 2000 WSU midge, model low mayfly:	0.6740	low from data
2000 WSU sed, oligochaete, 2000 WSU midge, literature high mayfly:	0.7983	
2000 WSU sed, oligochaete, 2000 WSU midge, literature low mayfly:	0.6840	low from data
2000 WSU sed, oligochaete, 2000 WSU midge, model high mayfly:	0.8442	high from data
2000 WSU sed, oligochaete, 2000 WSU midge, model low mayfly:	0.6846	

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1999 sed, modeled high midge, modeled high oligochaete, lit low mayfly	541.0136	
1999 sed, modeled high midge, modeled high oligochaete, lit high mayfly	541.1267	
1999 sed, modeled high midge, modeled high oligochaete, modeled low mayfly	541.0130	
1999 sed, modeled high midge, modeled high oligochaete, modeled high mayfly	541.1726	high from modeling
1999 sed, modeled high midge, modeled low oligochaete, lit low mayfly	0.2439	
1999 sed, modeled high midge, modeled low oligochaete, lit high mayfly	0.3582	
1999 sed, modeled high midge, modeled low oligochaete, modeled low mayfly	0.2445	
1999 sed, modeled high midge, modeled low oligochaete, modeled high mayfly	0.5827	
1999 sed, modeled low midge, modeled high oligochaete, lit low mayfly	540.8496	
1999 sed, modeled low midge, modeled high oligochaete, lit high mayfly	540.9639	
1999 sed, modeled low midge, modeled high oligochaete, modeled low mayfly	540.8501	
1999 sed, modeled low midge, modeled high oligochaete, modeled high mayfly	541.0097	
1999 sed, modeled low midge, modeled low oligochaete, lit low mayfly	0.0811	low from modeling
1999 sed, modeled low midge, modeled low oligochaete, lit high mayfly	0.1967	
1999 sed, modeled low midge, modeled low oligochaete, modeled low mayfly	0.0816	
1999 sed, modeled low midge, modeled low oligochaete, modeled high mayfly	0.2412	
2000 sed, modeled high midge, modeled high oligochaete, lit low mayfly	540.9705	
2000 sed, modeled high midge, modeled high oligochaete, lit high mayfly	541.0836	
2000 sed, modeled high midge, modeled high oligochaete, modeled low mayfly	540.9699	
2000 sed, modeled high midge, modeled high oligochaete, modeled high mayfly	541.1295	high from modeling
2000 sed, modeled high midge, modeled low oligochaete, lit low mayfly	0.2008	
2000 sed, modeled high midge, modeled low oligochaete, lit high mayfly	0.3151	
2000 sed, modeled high midge, modeled low oligochaete, modeled low mayfly	0.2014	
2000 sed, modeled high midge, modeled low oligochaete, modeled high mayfly	0.5396	
2000 sed, modeled low midge, modeled high oligochaete, lit low mayfly	540.8065	
2000 sed, modeled low midge, modeled high oligochaete, lit high mayfly	540.9208	
2000 sed, modeled low midge, modeled high oligochaete, modeled low mayfly	540.8070	
2000 sed, modeled low midge, modeled high oligochaete, modeled high mayfly	540.9666	
2000 sed, modeled low midge, modeled low oligochaete, lit low mayfly	0.0380	low from modeling
2000 sed, modeled low midge, modeled low oligochaete, lit high mayfly	0.1536	
2000 sed, modeled low midge, modeled low oligochaete, modeled low mayfly	0.0385	
2000 sed, modeled low midge, modeled low oligochaete, modeled high mayfly	0.1981	

Highs/Lows from above calculations to use in catfish/sucker modeling below:

Year	Food conc. (ug/g)	Source of input
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1999	0.6740	WSU data
1999	1.2596	WSU data
1999	0.0811	modeling
1999	541.1726	modeling
2000	0.6840	WSU data
2000	0.8442	WSU data
2000	0.0380	modeling
2000	541.1295	modeling

A) Calculation of Concentration in organism, Corg (catfish or white sucker), using parameters above

Original Thomann 1981 equation: $C_{org} = [(k_u \cdot C_w) + (CAE \cdot IR \cdot C_{food})] / k_e$; gives Corg for wet wt. of organism

Modified from Thomann (used below): $C_{org} = [(k_u \cdot C_w) + (CAE \cdot IR \cdot FAE \cdot C_{food})] / k_e$

Demersal fish interact directly with sediments while feeding

Since swim in water column, uptake from water will be assumed

1999 Calculation set, WSU data-based food conc. Of 0.6740 ug/g:

2000 Calculation set, WSU data-based food conc. Of 0.6840 ug/g:

ku (L/g/d)	Cw (ug/L; surface water)	CAE (chem. assim. efficiency; unitless)	IR (ingest rate; g/g wet bw/d)	FAE (food assim. efficiency; unitless, frac. of ingestion)	Food PCB conc. (ug/g)	ke (1/d)	
3.508	0.019	0.538	0.029	0.390	0.684	0.045	calc with means
0.129	0.019	0.330	0.013	0.130	0.684	0.003	calc with lowest values
18.000	0.019	0.800	0.058	0.700	0.684	0.250	calc with highest values
Corg (ug/g) for fish = 1.574 <i>using mean values for parameters</i>							
0.940 <i>using lowest values for parameters</i>							
1.457 <i>using highest values for parameters</i>							

1999 Calculation set, WSU data-based food conc. Of 0.6740 ug/g:

2000 Calculation set, WSU data-based food conc. Of 0.6840 ug/g:

ku (L/g/d)	Cw (ug/L; surface water)	CAE (chem. assim. efficiency; unitless)	IR (ingest rate; g/g wet bw/d)	FAE (food assim. efficiency; unitless, frac. of ingestion)	Food PCB conc. (ug/g)	ke (1/d)	
18.000	0.019	0.538	0.029	0.390	0.684	0.003	highest uptake lowest elim; all others means
18.000	0.019	0.538	0.029	0.390	0.684	0.250	highest uptake highest elim; all others means
0.129	0.019	0.538	0.029	0.390	0.684	0.003	lowest uptake lowest elim; all others means
0.129	0.019	0.538	0.029	0.390	0.684	0.250	lowest uptake highest elim; all others means

Corg (ug/g) for fish = 115.398	<i>highest uptake lowest elim; all others means</i>
1.385	<i>highest uptake highest elim; all others means</i>
2.215	<i>lowest uptake lowest elim; all others means</i>
0.027	<i>lowest uptake highest elim; all others means</i>

1999 Calculation set, WSU data-based food conc. Of 0.6740 ug/g:

2000 Calculation set, WSU data-based food conc. Of 0.6840 ug/g:

ku (L/g/d)	Cw (ug/L; surface water)	CAE (chem. assim. efficiency; unitless)	IR (ingest rate; g/g wet bw/d)	FAE (food assim. efficiency; unitless, frac. of ingestion)	Food PCB conc. (ug/g)	ke (1/d)	
18.000	0.019	0.330	0.013	0.130	0.684	0.003	highest uptake lowest elim; all others lowest
18.000	0.019	0.330	0.013	0.130	0.684	0.250	highest uptake highest elim; all others lowest
0.129	0.019	0.330	0.013	0.130	0.684	0.003	lowest uptake lowest elim; all others lowest
0.129	0.019	0.330	0.013	0.130	0.684	0.250	lowest uptake highest elim; all others lowest
Corg (ug/g) for fish = 114.123							<i>highest uptake lowest elim; all others lowest</i>
1.369							<i>highest uptake highest elim; all others lowest</i>
0.940							<i>lowest uptake lowest elim; all others lowest</i>
0.01128							<i>lowest uptake highest elim; all others lowest</i>

1999 Calculation set, WSU data-based food conc. Of 0.6740 ug/g:

2000 Calculation set, WSU data-based food conc. Of 0.6840 ug/g:

ku (L/g/d)	Cw (ug/L; surface water)	CAE (chem. assim. efficiency; unitless)	IR (ingest rate; g/g wet bw/d)	FAE (food assim. efficiency; unitless, frac. of ingestion)	Food PCB conc. (ug/g)	ke (1/d)	
18.000	0.019	0.800	0.058	0.700	0.684	0.003	highest uptake lowest elim; all others highest
18.000	0.019	0.800	0.058	0.700	0.684	0.250	highest uptake highest elim; all others highest
0.129	0.019	0.800	0.058	0.700	0.684	0.003	lowest uptake lowest elim; all others highest
0.129	0.019	0.800	0.058	0.700	0.684	0.250	lowest uptake highest elim; all others highest
Corg (ug/g) for fish = 121.405							<i>highest uptake lowest elim; all others highest</i>
1.457							<i>highest uptake highest elim; all others highest</i>
8.222							<i>lowest uptake lowest elim; all others highest</i>
0.099							<i>lowest uptake highest elim; all others highest</i>

1999 Calculation set, WSU data-based food conc. Of 1.260 ug/g:

2000 Calculation set, WSU data-based food conc. Of 0.844 ug/g:

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ku (L/g/d)	Cw (ug/L; surface water)	CAE (chem. assim. efficiency; unitless)	IR (ingest rate; g/g wet bw/d)	F AE (food assim. efficiency; unitless, frac. of ingestion)	Food PCB conc. (ug/g)	ke (1/d)
3.508	0.019	0.538	0.029	0.390	0.844	0.045 calc with means
0.129	0.019	0.330	0.013	0.130	0.844	0.003 calc with lowest values
18.000	0.019	0.800	0.058	0.700	0.844	0.250 calc with highest values
Corg (ug/g) for fish = 1.596 <i>using mean values for parameters</i>						
0.969 <i>using lowest values for parameters</i>						
1.478 <i>using highest values for parameters</i>						

1999 Calculation set, WSU data-based food conc. Of 1.260 ug/g:

2000 Calculation set, WSU data-based food conc. Of 0.844 ug/g:

ku (L/g/d)	Cw (ug/L; surface water)	CAE (chem. assim. efficiency; unitless)	IR (ingest rate; g/g wet bw/d)	F AE (food assim. efficiency; unitless, frac. of ingestion)	Food PCB conc. (ug/g)	ke (1/d)
18.000	0.019	0.538	0.029	0.390	0.844	0.003 highest uptake lowest elim; all others means
18.000	0.019	0.538	0.029	0.390	0.844	0.250 highest uptake highest elim; all others means
0.129	0.019	0.538	0.029	0.390	0.844	0.003 lowest uptake lowest elim; all others means
0.129	0.019	0.538	0.029	0.390	0.844	0.250 lowest uptake highest elim; all others means
Corg (ug/g) for fish = 115.725 <i>highest uptake lowest elim; all others means</i>						
1.389 <i>highest uptake highest elim; all others means</i>						
2.542 <i>lowest uptake lowest elim; all others means</i>						
0.031 <i>lowest uptake highest elim; all others means</i>						

1999 Calculation set, WSU data-based food conc. Of 1.260 ug/g:

2000 Calculation set, WSU data-based food conc. Of 0.844 ug/g:

ku (L/g/d)	Cw (ug/L; surface water)	CAE (chem. assim. efficiency; unitless)	IR (ingest rate; g/g wet bw/d)	F AE (food assim. efficiency; unitless, frac. of ingestion)	Food PCB conc. (ug/g)	ke (1/d)
18.000	0.019	0.330	0.013	0.130	0.844	0.003 highest uptake lowest elim; all others lowest
18.000	0.019	0.330	0.013	0.130	0.844	0.250 highest uptake highest elim; all others lowest
0.129	0.019	0.330	0.013	0.130	0.844	0.003 lowest uptake lowest elim; all others lowest
0.129	0.019	0.330	0.013	0.130	0.844	0.250 lowest uptake highest elim; all others lowest
Corg (ug/g) for fish = 114.152 <i>highest uptake lowest elim; all others lowest</i>						
1.370 <i>highest uptake highest elim; all others lowest</i>						
0.969 <i>lowest uptake lowest elim; all others lowest</i>						
0.0116 <i>lowest uptake highest elim; all others lowest</i>						

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1999 Calculation set, WSU data-based food conc. Of 1.260 ug/g:

2000 Calculation set, WSU data-based food conc. Of 0.844 ug/g:

ku (L/g/d)	Cw (ug/L; surface water)	CAE (chem. assim. efficiency; unitless)	IR (ingest rate; g/g wet bw/d)	FAE (food assim. efficiency; unitless, frac. of ingestion)	Food PCB conc. (ug/g)	ke (1/d)	
18.000	0.019	0.800	0.058	0.700	0.844	0.003	highest uptake lowest elim; all others highest
18.000	0.019	0.800	0.058	0.700	0.844	0.250	highest uptake highest elim; all others highest
0.129	0.019	0.800	0.058	0.700	0.844	0.003	lowest uptake lowest elim; all others highest
0.129	0.019	0.800	0.058	0.700	0.844	0.250	lowest uptake highest elim; all others highest
Corg (ug/g) for fish = 123.140							
	1.478						highest uptake lowest elim; all others highest
	1.478						highest uptake highest elim; all others highest
	9.957						lowest uptake lowest elim; all others highest
	0.119						lowest uptake highest elim; all others highest

Summary of 1999 Calculation set, WSU data-based food conc.

Range of values for Corg among all parameter combinations: 0.01952 - 223.642 ug/g wet wt. OR 19.52 - 223642 ug/kg wet wt.

Corg using mean parameter values: 2.820 ug/g wet wt. OR 2820 ug/kg wet wt,
2.900 ug/g wet wt. OR 2900 ug/kg wet wt,

Summary of 2000 Calculation set, WSU data-based food conc.

Range of values for Corg among all parameter combinations: 0.01128 - 123.140 ug/g wet wt. OR 11.28 - 123104 ug/kg wet wt.

Corg using mean parameter values: 1.574 ug/g wet wt. OR 1574 ug/kg wet wt,
1.596 ug/g wet wt. OR 1596 ug/kg wet wt,

OEPA observed mean fish concentrations for 3 species in Dicks Creek of 463.5 - 9527 ug/kg

Therefore, the calculations above are within the range for field observations.

1999 Calculation set, model-based food conc. Of 0.0811 ug/g:

ku (L/g/d)	Cw (ug/L; surface water)	CAE (chem. assim. efficiency; unitless)	IR (ingest rate; g/g wet bw/d)	FAE (food assim. efficiency; unitless, frac. of ingestion)	Food PCB conc. (ug/g)	ke (1/d)	
3.508	0.035	0.538	0.029	0.390	0.0811	0.045	calc with means
0.129	0.035	0.330	0.013	0.130	0.0811	0.003	calc with lowest values

AK5 041772

Appendix A4

18.000 0.035 0.800 0.058 0.700 0.0811 0.250 calc with highest values

Corg (ug/g) for fish = 2.739 *using mean values for parameters*
 1.52 *using lowest values for parameters*
 2.53 *using highest values for parameters*

1999 Calculation set, model-based food conc. Of 0.0811 ug/g:

ku (L/g/d)	Cw (ug/L; surface water)	CAE (chem. assim. efficiency; unitless)	IR (ingest rate; g/g wet bw/d)	FAE (food assim. efficiency; unitless, frac. of ingestion)	Food PCB conc. (ug/g)	ke (1/d)	
18.000	0.035	0.538	0.029	0.390	0.0811	0.003	highest uptake lowest elim; all others means
18.000	0.035	0.538	0.029	0.390	0.0811	0.250	highest uptake highest elim; all others means
0.129	0.035	0.538	0.029	0.390	0.0811	0.003	lowest uptake lowest elim; all others means
0.129	0.035	0.538	0.029	0.390	0.0811	0.250	lowest uptake highest elim; all others means
Corg (ug/g) for fish = 210.166			<i>highest uptake lowest elim; all others means</i>				
2.522			<i>highest uptake highest elim; all others means</i>				
1.671			<i>lowest uptake lowest elim; all others means</i>				
0.020			<i>lowest uptake highest elim; all others means</i>				

1999 Calculation set, model-based food conc. Of 0.0811 ug/g:

ku (L/g/d)	Cw (ug/L; surface water)	CAE (chem. assim. efficiency; unitless)	IR (ingest rate; g/g wet bw/d)	FAE (food assim. efficiency; unitless, frac. of ingestion)	Food PCB conc. (ug/g)	ke (1/d)	
18.000	0.035	0.330	0.013	0.130	0.0811	0.003	highest uptake lowest elim; all others lowest
18.000	0.035	0.330	0.013	0.130	0.0811	0.250	highest uptake highest elim; all others lowest
0.129	0.035	0.330	0.013	0.130	0.0811	0.003	lowest uptake lowest elim; all others lowest
0.129	0.035	0.330	0.013	0.130	0.0811	0.250	lowest uptake highest elim; all others lowest
Corg (ug/g) for fish = 210.015			<i>highest uptake lowest elim; all others lowest</i>				
2.520			<i>highest uptake highest elim; all others lowest</i>				
1.520			<i>lowest uptake lowest elim; all others lowest</i>				
0.01824			<i>lowest uptake highest elim; all others lowest</i>				

1999 Calculation set, model-based food conc. Of 0.0811 ug/g:

ku (L/g/d)	Cw (ug/L; surface water)	CAE (chem. assim. efficiency; unitless)	IR (ingest rate; g/g wet bw/d)	FAE (food assim. efficiency; unitless, frac. of ingestion)	Food PCB conc. (ug/g)	ke (1/d)	
18.000	0.035	0.800	0.058	0.700	0.0811	0.003	highest uptake lowest elim; all others highest

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18.000	0.035	0.800	0.058	0.700	0.0811	0.250	highest uptake highest elim; all others highest
0.129	0.035	0.800	0.058	0.700	0.0811	0.003	lowest uptake lowest elim; all others highest
0.129	0.035	0.800	0.058	0.700	0.0811	0.250	lowest uptake highest elim; all others highest

Corg (ug/g) for fish = 210.878	<i>highest uptake lowest elim; all others highest</i>
2.531	<i>highest uptake highest elim; all others highest</i>
2.383	<i>lowest uptake lowest elim; all others highest</i>
0.029	<i>lowest uptake highest elim; all others highest</i>

1999 Calculation set, model-based food conc. Of 541.1726 ug/g:

ku (L/g/d)	Cw (ug/L; surface water)	CAE (chem. assim. efficiency; unitless)	IR (ingest rate; g/g wet bw/d)	FAE (food assim. efficiency; unitless, frac. of ingestion)	Food PCB conc. (ug/g)	ke (1/d)	
3.508	0.035	0.538	0.029	0.390	541.1726	0.045	calc with means
0.129	0.035	0.330	0.013	0.130	541.1726	0.003	calc with lowest values
18.000	0.035	0.800	0.058	0.700	541.1726	0.250	calc with highest values
Corg (ug/g) for fish = 76.463	<i>using mean values for parameters</i>						
99.01	<i>using lowest values for parameters</i>						
72.83	<i>using highest values for parameters</i>						

1999 Calculation set, model-based food conc. Of 541.1726 ug/g:

ku (L/g/d)	Cw (ug/L; surface water)	CAE (chem. assim. efficiency; unitless)	IR (ingest rate; g/g wet bw/d)	FAE (food assim. efficiency; unitless, frac. of ingestion)	Food PCB conc. (ug/g)	ke (1/d)	
18.000	0.035	0.538	0.029	0.390	541.1726	0.003	highest uptake lowest elim; all others means
18.000	0.035	0.538	0.029	0.390	541.1726	0.250	highest uptake highest elim; all others means
0.129	0.035	0.538	0.029	0.390	541.1726	0.003	lowest uptake lowest elim; all others means
0.129	0.035	0.538	0.029	0.390	541.1726	0.250	lowest uptake highest elim; all others means
Corg (ug/g) for fish = 1316.013	<i>highest uptake lowest elim; all others means</i>						
15.792	<i>highest uptake highest elim; all others means</i>						
1107.518	<i>lowest uptake lowest elim; all others means</i>						
13.290	<i>lowest uptake highest elim; all others means</i>						

1999 Calculation set, model-based food conc. Of 541.1726 ug/g:

ku (L/g/d)	Cw (ug/L; surface water)	CAE (chem. assim. efficiency; unitless)	IR (ingest rate; g/g wet bw/d)	FAE (food assim. efficiency; unitless, frac. of ingestion)	Food PCB conc. (ug/g)	ke (1/d)	
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AK5 041774

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18.000	0.035	0.330	0.013	0.130	541.1726	0.003	highest uptake lowest elim; all others lowest
18.000	0.035	0.330	0.013	0.130	541.1726	0.250	highest uptake highest elim; all others lowest
0.129	0.035	0.330	0.013	0.130	541.1726	0.003	lowest uptake lowest elim; all others lowest
0.129	0.035	0.330	0.013	0.130	541.1726	0.250	lowest uptake highest elim; all others lowest

Corg (ug/g) for fish = 307.508	<i>highest uptake lowest elim; all others lowest</i>
3.690	<i>highest uptake highest elim; all others lowest</i>
99.013	<i>lowest uptake lowest elim; all others lowest</i>
1.188	<i>lowest uptake highest elim; all others lowest</i>

1999 Calculation set, model-based food conc. Of 541.1726 ug/g:

ku (L/g/d)	Cw (ug/L; surface water)	CAE (chem. assim. efficiency; unitless)	IR (ingest rate; g/g wet bw/d)	FAE (food assim. efficiency; unitless, frac. of ingestion)	Food PCB conc. (ug/g)	ke (1/d)	
18.000	0.035	0.800	0.058	0.700	541.1726	0.003	highest uptake lowest elim; all others highest
18.000	0.035	0.800	0.058	0.700	541.1726	0.250	highest uptake highest elim; all others highest
0.129	0.035	0.800	0.058	0.700	541.1726	0.003	lowest uptake lowest elim; all others highest
0.129	0.035	0.800	0.058	0.700	541.1726	0.250	lowest uptake highest elim; all others highest
Corg (ug/g) for fish = 6069.095	<i>highest uptake lowest elim; all others highest</i>						
72.829	<i>highest uptake highest elim; all others highest</i>						
5860.600	<i>lowest uptake lowest elim; all others highest</i>						
70.327	<i>lowest uptake highest elim; all others highest</i>						

1999 Calculation set, model-based food conc.

Range of values for Corg among all parameter combinations: 0.01824 - 6069.095 ug/g wet wt. OR 18.24 - 6069095 ug/kg wet wt.

Corg using mean parameter values: 2.739 ug/g wet wt. OR 2739 ug/kg wet wt,
76.463 ug/g wet wt. OR 76463 ug/kg wet wt,

OEPA observed mean fish concentrations for 3 species in Dicks Creek of 463.5 - 9527 ug/kg

Therefore, the calculations above are within the range for field observations but range very widely
Recommend the use of above calculations based on measured tissue residues in low trophic level species

2000 Calculation set, model-based food conc. NOT CALCULATED

B) Estimate the catfish/sucker tissue conc. using literature BSAFs, BAF or BCF

- (1) MacDonald, C. R., et al., Environ. Toxicol. Chem. 12:1991-2003, 1993.
- (2) Dabrowska, H. et al., Environ. Toxicol. Chem. 15(5):746-749, 1996.
- (3) SLERAP, 1999
- (4) Van Wezel, A.P. et al., Environ. Toxicol. Chem. 19(8):2140-2153, 2000
- (5) Gale et al., Environ. Sci. Technol. 31(1):178-187, 1997

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(6) Sijm, D. T. H. M. and van der Linde, A., Environ. Sci. Technol. 29(11):2769-2777, 1995

(7) Leblanc, G. A., Environ. Sci. Technol. 29(10):154-160, 1995

BSAFs = (ug/kg lipid) / (ug/kg oc)

1999				
Citation	BSAF	notes	Cs (ug/kg oc)	C _{fish} (ug/kg lipid)
1	13.2	total PCBs	14761.6	194853.12
1	13.8	total PCBs	14761.6	203710.08 high
1	2.8	total PCBs	14761.6	41332.48
1	4.3	total PCBs	14761.6	63474.88
4	1.1	total PCBs	14761.6	16237.76
4	5.5	total PCBs	14761.6	81188.80
4	7.1	total PCBs	14761.6	104807.36
4	5.7	total PCBs	14761.6	84141.12
4	10	total PCBs	14761.6	147616.00
4	6.1	total PCBs	14761.6	90045.76
4	3	total PCBs	14761.6	44284.80
4	2.5	total PCBs	14761.6	36904.00
1	1.6	total PCBs	14761.6	23618.56 low
1	3.1	total PCBs	14761.6	45760.96

2000	
Cs (ug/g oc)	C _{fish} (ug/kg lipid)
4651.8	61403.76
4651.8	64194.84 high
4651.8	13025.04
4651.8	20002.74
4651.8	5116.98 low
4651.8	25584.90
4651.8	33027.78
4651.8	26515.26
4651.8	46518.00
4651.8	28375.98
4651.8	13955.40
4651.8	11629.50
4651.8	7442.88
4651.8	14420.58

BAFs = (ug/g lipid tissue) / (ug/g lipid food)

lowest measured food conc. (mayfly)				
Citation	BAF	notes	C _f (ug/kg lipid)	C _{fish} (ug/kg lipid)
1	1.7	total PCBs in inverts	218.9	372.13 high
1	1.6	total PCBs in inverts	218.9	350.24
1	0.4	total PCBs in inverts	218.9	87.56 low
1	0.6	total PCBs in inverts	218.9	131.34

AK5 041776

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1	1.2 total PCBs in inverts	218.9	262.68
1	1.9 total PCBs in inverts	218.9	415.91
2	1.38 total PCBs for catfish	218.9	302.082
2	1.66 total PCBs for catfish	218.9	363.374

highest measured food conc. (*L. variegatus*)

Cf (ug/kg lipid)	C _{fish} (ug/kg lipid)
130116	221197.2 high
130116	208185.6
130116	52046.4 low
130116	78069.6
130116	156139.2
130116	247220.4
130116	179560.08
130116	215992.56

BSAF-based range from above: 5116 - 203710 ug/kg lipid

BAF-lipid-based range from above: 88 - 221197 ug/kg lipid

OEPA data on 3 species of fish from Dicks Creek (ug/kg lipid):

range:	4059 - 488930
mean catfish	13632
mean carp	175769
mean white sucker	46231
mean overall	92433

The BSAF and BAF models provide good estimation of demersal fish tissue contamination by PCBs

BCF = (ug/kg wet fish) / (ug/L water)

Food chain multipliers for Trophic level 3 (ie., catfish and white sucker)
from SLERAP, 1999 and Oak Ridge document

Compound	log Kow	FCM
Aroclor 1248	6.2	12.064
Aroclor 1254	6.5	13.662
mean		12.863

Use SLERAP, 1999 approach to estimate COPC conc. in fish (equation 5-7; pg. 5-14)

$$C_{\text{fish}} = \text{BCF} * \text{FCM} * C_w$$

Citation	species	note	BCF	FCM	1999	
					C _w (ug/L)	C _{fish} (ug/kg wet wt)
3	general; all fish	Aroclor 1016	22649	12.863	0.035	10196.69
3	general; all fish	Aroclor 1254	230394	12.863	0.035	103724.53
3	fathead	Aroclor 1254	35481	12.863	0.035	15973.72

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3	fathead	Aroclor 1254	354813	12.863	0.035	159738.59	
3	rainbow tr	Aroclor 1254	46000	12.863	0.035	20709.43	
3	channel cat	Aroclor 1254	61200	12.863	0.035	27552.55	
3	field collected	Aroclor 1254	133000	12.863	0.035	59877.27	
5	channel cat	tetra & pentaCB	3162.27766	12.863	0.035	1423.67	lowest
6	fathead	tetraCB	28840.31503	12.863	0.035	12984.05	
6	fathead	tetraCB	72443.59601	12.863	0.035	32614.47	
6	fathead	tetraCB	389045.145	12.863	0.035	175150.07	
6	fathead	tetraCB	338844.1561	12.863	0.035	152549.33	
6	fathead	tetraCB	51286.1384	12.863	0.035	23089.28	
6	fathead	tetraCB	64565.4229	12.863	0.035	29067.68	
6	fathead	hexaCB	1513561.248	12.863	0.035	681412.84	highest
6	fathead	hexaCB	1288249.552	12.863	0.035	579976.39	
6	fathead	hexaCB	21877.61624	12.863	0.035	9849.41	
6	fathead	hexaCB	478630.0923	12.863	0.035	215481.66	
7	general; all fish	Aroclor 1254	40667	12.863	0.035	18308.49	
7	general; all fish	Aroclor 1254	49050	12.863	0.035	22082.56	
7	general; all fish	Aroclor 1254	57433	12.863	0.035	25856.62	
7	general; all fish	Aroclor 1242	27400	12.863	0.035	12335.62	

Year	Species	Total PCBs (ug/kg)
1996	Channel Cat	620
1998	Channel Cat	307
1996	Carp	220
1998	Carp	26500
1998	Carp	1860
1998	White Sucker	4190
1998	White Sucker	1820
Mean	Channel Cat	463.5
Stdev	Channel Cat	221.3244225
Mean	Carp	9526.666667
Stdev	Carp	14722.19187
Mean	White Sucker	3005
Stdev	White Sucker	1675.843071
Mean	Overall	5073.857143
Stdev	Overall	9547.224421

BCF-based range from above:

if all species BCFs used: 1423.7 - 681413 ug/kg wet

if only catfish BCFs used: 1423.7 - 27552 ug/kg wet

OEPA data on 3 species of fish from Dicks Creek (ug/kg wet):

range:	220 - 26500
mean catfish	463.50
mean carp	9526.67
mean white sucker	3005.00

AK5 041778

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mean overall 5073.86

The BCF models provide good adequate estimation of demersal fish tissue contamination by PCBs

AK5 041779

Appendix 5

Appendix A5: 1a. OEPA fish data from Dicks Creek (demersal species only) 1b. Lipid levels of demersal fish:

Year	Species	Total PCBs (ug/kg)	Total PCBs (ug/kg lipid) using mean lipid data from lit	Species	frac lipid
1996	hannel Ca	620	18235.29	channel ca	0.0260
1998	hannel Ca	307	9029.41	channel ca	0.0380
1996	Carp	220	4059.04	channel ca	0.0390
1998	Carp	26500	488929.89	channel ca	0.0300
1998	Carp	1860	34317.34	channel ca	0.0370
1998	hite Suck	4190	64461.54	<i>C. carpio</i>	0.0840
1998	hite Suck	1820	28000.00	<i>C. carpio</i>	0.0387
				<i>C. carpio</i>	0.0399
	<i>Mean Channel C</i>	463.50	13632.35	white suck	0.0800
	<i>Stdev Channel C</i>	221.32	6509.54	white suck	0.0500
	<i>Mean Carp</i>	9526.67	175768.76	<i>stdev channel cat</i>	0.0340
	<i>Stdev Carp</i>	14722.19	271627.16	<i>mean channel cat</i>	0.0057
	<i>Mean White Suc</i>	3005.00	46230.77	<i>mean carp</i>	0.0542
	<i>Stdev White Suc</i>	1675.84	25782.20	<i>stdev carp</i>	0.0258
	<i>Mean Overall</i>	5073.86	92433.22	<i>mean white sucker</i>	0.0650
	<i>Stdev Overall</i>	9547.22	175970.00	<i>stdev white sucker</i>	0.0212

Calculate accumulation by Belted Kingfisher

A1) SLERAP approach

Can use tissue levels estimated from step 2 as fish prey item PCB level: but choose OEPA value

for catfish of 0.620 mg/kg as it is a real data point

Assume that all uptake is from food (disregard water and sediment)

AK5 041780

Appendix 5

Assume 86% diet is fish (realistic for Ohio as cited in Wildlife Exposure Factors Handbook (EPA, 1993)

Assume that 10, 50, 100% of food items are contaminated since birds may forage in areas other than Dicks Creek

Assume that uptake from ingested water and/or sediment is negligible

Ingestion rate from Wildlife Exposure Factors Handbook (EPA, 1993)

Use equation 5-1 from SLERAP for daily dose

Estimate of Daily Dose:

	Ingest rate (kg/kg BW- day)	COPC conc. in food fish (mg/kg)	Proportion food that is contaminated	Fraction diet consisting of fish	Daily Dose (mg COPC/kg BW- day)
EPA fish meas	0.5	0.62	0.5	0.86	0.1333
	0.5	0.31	0.5	0.86	0.066005
	0.5	0.22	0.5	0.86	0.0473
	0.5	26.50	0.5	0.86	5.6975
	0.5	1.86	0.5	0.86	0.3999
	0.5	4.19	0.5	0.86	0.90085
	0.5	1.82	0.5	0.86	0.3913
	1	0.62	0.5	0.86	0.2666
	1	0.31	0.5	0.86	0.13201
	1	0.22	0.5	0.86	0.0946
	1	26.50	0.5	0.86	11.395
	1	1.86	0.5	0.86	0.7998
	1	4.19	0.5	0.86	1.8017
	1	1.82	0.5	0.86	0.7826
	1.75	0.62	0.5	0.86	0.46655
	1.75	0.31	0.5	0.86	0.2310175
	1.75	0.22	0.5	0.86	0.16555
	1.75	26.50	0.5	0.86	19.94125
	1.75	1.86	0.5	0.86	1.39965
	1.75	4.19	0.5	0.86	3.152975
	1.75	1.82	0.5	0.86	1.36955

AK5 041781

Appendix 5

Using all OEPA fish data to calculate ranges

With a 100% food contamination assumption, range is: 0.0946 - 39.9 mg/kg bw/d

With a 50% food contamination assumption, range is: 0.047 - 19.9 mg/kg bw/d

With a 10% food contamination assumption, range is: 0.0095 - 3.99 mg/kg bw/d

Compared to kingfishers in Moore, DRJ et al., ET&C 18(12): 2941-2953, 1999

many of these values within exposure mg/kg bw/day values for kingfishers in Figs. 5-6

50th percentile values are from 0.068 mg/kg bw/day to 0.327 mg/kg bw/day

B) SLERAP calculation of COPC tissue conc. in kingfisher

Food chain multipliers for Trophic level 3 (ie., catfish and white sucker)
and Trophic level 4 (i.e., piscivorous birds and mammals)
from SLERAP, 1999 and Oak Ridge document

Compound	log Kow	TL	FCM
Aroclor 1248	6.2	3	12.064
Aroclor 1254	6.5	3	13.662
		<i>mean</i>	<i>12.863</i>
Aroclor 1248	6.2	4	19.907
Aroclor 1254	6.5	4	24.604
		<i>mean</i>	<i>22.2555</i>

Use equation 5-13 (relies on food chain multipliers, FCM)

Same assumptions as above for fish consumption of prey

Focus on PCBs that have log Kow between 4-7

	COPC conc. in food fish (mg/kg)	FCM kingfisher in TL4	FCM Fish in TL3	Fraction diet consisting of fish	Proportion food that is contaminated	COPC conc. In kingfisher (mg/kg)	
log Kow = 4	0.4635	1.1	1.3	0.86	0.1	0.0337	using mean catfish
log Kow = 5	0.4635	2.6	3.2	0.86	0.1	0.0324	
log Kow = 5.4	0.4635	5.8	5.5	0.86	0.1	0.0420	

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Appendix 5

log Kow = 6	0.4635	16	11	0.86	0.1	0.0580	
log Kow = 7	0.4635	26	14	0.86	0.1	0.0740	
Aroclor 1248	0.4635	19.907	12.064	0.86	0.1	0.0658	
Aroclor 1254	0.4635	24.604	13.662	0.86	0.1	0.0718	
log Kow = 4	9.527	1.1	1.3	0.86	0.1	0.6933	using mean carp
log Kow = 5	9.527	2.6	3.2	0.86	0.1	0.6657	
log Kow = 5.4	9.527	5.8	5.5	0.86	0.1	0.8640	
log Kow = 6	9.527	16	11	0.86	0.1	1.1917	
log Kow = 7	9.527	26	14	0.86	0.1	1.5216	
Aroclor 1248	9.527	19.907	12.064	0.86	0.1	1.3520	
Aroclor 1254	9.527	24.604	13.662	0.86	0.1	1.4755	
log Kow = 4	3.005	1.1	1.3	0.86	0.1	0.2187	using mean white sucker
log Kow = 5	3.005	2.6	3.2	0.86	0.1	0.2100	
log Kow = 5.4	3.005	5.8	5.5	0.86	0.1	0.2725	
log Kow = 6	3.005	16	11	0.86	0.1	0.3759	
log Kow = 7	3.005	26	14	0.86	0.1	0.4799	
Aroclor 1248	3.005	19.907	12.064	0.86	0.1	0.4264	
Aroclor 1254	3.005	24.604	13.662	0.86	0.1	0.4654	
log Kow = 4	5.074	1.1	1.3	0.86	0.1	0.3692	using mean overall
log Kow = 5	5.074	2.6	3.2	0.86	0.1	0.3545	
log Kow = 5.4	5.074	5.8	5.5	0.86	0.1	0.4602	
log Kow = 6	5.074	16	11	0.86	0.1	0.6347	
log Kow = 7	5.074	26	14	0.86	0.1	0.8104	
Aroclor 1248	5.074	19.907	12.064	0.86	0.1	0.7201	
Aroclor 1254	5.074	24.604	13.662	0.86	0.1	0.7859	

Using all OEPA mean data for each fish species, then over all mean to calculate ranges

With a 100% food contamination assumption, range is:

	0.324 - 15.22 mg/kg fresh wt
Aroclor 1248 only	0.659 - 13.52 mg/kg fresh wt
Aroclor 1254 only	0.718 - 14.75 mg/kg fresh wt

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Appendix 5

With a 50% food contamination assumption, range is:	0.162 - 7.61 mg/kg fresh wt
Aroclor 1248 only	0.329 - 6.76 mg/kg fresh wt
Aroclor 1254 only	0.359 - 7.38 mg/kg fresh wt
With a 10% food contamination assumption, range is:	0.032 - 1.52 mg/kg fresh wt
Aroclor 1248 only	0.066 - 1.35 mg/kg fresh wt
Aroclor 1254 only	0.072 - 1.47 mg/kg fresh wt

C) How do these estimated kingfisher tissue levels in 3A,B compare to literature?

5.9 mg/kg dry wt., Total PCBs in common murre (Jarman, WM et al., ES&T 30(2): 654-660, Feb 1996)

0.02-105 mg/kg wet wt., Total PCBs in sea birds, raptors and herons (Boumphrey, RS et al., Arch. Environ. Contam. Toxicol. 25(3): 346-352, Sept 1993)

26 mg/kg lipid, maximum single congener level (would be 0.52 or 2.6 mg/kg or if assume 2% or 10% lipids, resp.)

Zimmermann, G et al., Chemosphere 34(5-7): 1379-1388, Mar-Apr 1997.

Reported fat content for belted kingfisher is 8.9 (9.0 SD) (Van Wezel, A.P. et al., Environ. Toxicol. Chem. 19(8):2140-2153, 2000)

More data for comparisons can be found in the literature

AK5 041784

Dicks Creek ERA

HQs for in situ exposed *L. variegatus* and *C. tentans*

$$HQ = EEL/TRV$$

HQ = Ecological screening quotient

EEL = Expected ecological level (mass COPC/mass body or mass COPC/mass body/d)

TRV = Toxicity reference value (mass COPC/mass body or mass COPC/mass body/d)

HQs calculated using bioaccumulation data from WSU

Tissue concentration = EEL

Organism	Year	Treatment	Site on Dicks Creek	Tissue Concentration (ng/g wet wt)	Tissue Concentration (mg/kg wet wt)	Mortality LOAEL HQ or Weight Loss LOAEL HQ		Mortality NOAEL HQ or Weight Loss NOAEL HQ	
<i>L. variegatus</i>	2000	WC	Amanda	238.279	0.2383	0.0023	mean	0.0040	mean
<i>L. variegatus</i>	2000	AS	Amanda	205.998	0.2060	0.0020	0.0027	0.0035	0.0048
<i>L. variegatus</i>	2000	SS	Amanda	26.083	0.0261	0.0002	stdev	0.0004	stdev
<i>L. variegatus</i>	2000	PWC	Amanda	676.601	0.6766	0.0064	0.0026	0.0114	0.0047
<i>L. variegatus</i>	2000	WC	USGS	249.485	0.2495	0.0024	mean	0.0042	mean
<i>L. variegatus</i>	2000	AS	USGS	353.646	0.3536	0.0034	0.1024	0.0060	0.1826
<i>L. variegatus</i>	2000	SS	USGS	42055.246	42.0552	0.3986	stdev	0.7112	stdev
<i>L. variegatus</i>	2000	PWC	USGS	536.342	0.5363	0.0051	0.1975	0.0091	0.3524
<i>L. variegatus</i>	1999	WC	Amanda	30.497	0.0305	0.0003	mean	0.0005	mean
<i>L. variegatus</i>	1999	AS	Amanda	104.874	0.1049	0.0010	0.0013	0.0018	0.0023
<i>L. variegatus</i>	1999	SS	Amanda	344.233	0.3442	0.0033	stdev	0.0058	stdev
<i>L. variegatus</i>	1999	PWC	Amanda	57.887	0.0579	0.0005	0.0014	0.0010	0.0024
<i>L. variegatus</i>	1999	WC	BD	125.778	0.1258	0.0012	mean	0.0021	mean
<i>L. variegatus</i>	1999	AS	BD	103.158	0.1032	0.0010	0.0014	0.0017	0.0025
<i>L. variegatus</i>	1999	SS	BD	266.448	0.2664	0.0025	stdev	0.0045	stdev

Appendix 6

<i>L. variegatus</i>	1999	PWC	BD	105.210	0.1052	0.0010	0.0007	0.0018	0.0013
<i>C. tentans</i>	2000	AS	USGS	94.342	0.0943	0.0009	mean	0.0016	mean
<i>C. tentans</i>	2000	SS	USGS	7434.862	7.4349	0.0705	0.0357	0.1257	0.0637
							stdev		stdev
							0.0492		0.0878
<i>L. variegatus</i>	1997	core chamber	Landfill Trib.	19000	19.0000	0.1801		0.3213	
<i>Indig. oligochaetes</i>	1997	field collected	Landfill Trib.	8333	8.3330	0.0790		0.1409	

HQ for Mortality LOAEL; TRVs as tissue concentrations (mg/kg wet wt)

also same as HQ for Weight Loss LOAEL

use *L. variegatus* TRV for *C. tentans*

TRVs from USEPA Hudson ERA

Organism	Mortality LOAEL - 1SD	Mortality LOAEL Mean	Mortality LOAEL + 1SD	HQ _{mortality-L, low}	HQ _{mortality-L, mea}	HQ _{mortality-L, high}
<i>L. variegatus</i>	77.33	105.5	133.67	0.0031	0.0023	0.0018
<i>L. variegatus</i>	77.33	105.5	133.67	0.0027	0.0020	0.0015
<i>L. variegatus</i>	77.33	105.5	133.67	0.0003	0.0002	0.0002
<i>L. variegatus</i>	77.33	105.5	133.67	0.0087	0.0064	0.0051
<i>L. variegatus</i>	77.33	105.5	133.67	0.0032	0.0024	0.0019
<i>L. variegatus</i>	77.33	105.5	133.67	0.0046	0.0034	0.0026
<i>L. variegatus</i>	77.33	105.5	133.67	0.5438	0.3986	0.3146
<i>L. variegatus</i>	77.33	105.5	133.67	0.0069	0.0051	0.0040
<i>L. variegatus</i>	77.33	105.5	133.67	0.0004	0.0003	0.0002
<i>L. variegatus</i>	77.33	105.5	133.67	0.0014	0.0010	0.0008
<i>L. variegatus</i>	77.33	105.5	133.67	0.0045	0.0033	0.0026
<i>L. variegatus</i>	77.33	105.5	133.67	0.0007	0.0005	0.0004
<i>L. variegatus</i>	77.33	105.5	133.67	0.0016	0.0012	0.0009
<i>L. variegatus</i>	77.33	105.5	133.67	0.0013	0.0010	0.0008

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Appendix 6

<i>L. variegatus</i>	77.33	105.5	133.67	0.0034	0.0025	0.0020
<i>L. variegatus</i>	77.33	105.5	133.67	0.0014	0.0010	0.0008
<i>C. tentans</i>	77.33	105.5	133.67	0.0012	0.0009	0.0007
<i>C. tentans</i>	77.33	105.5	133.67	0.0961	0.0705	0.0556
<i>L. variegatus</i>	77.33	105.5	133.67	0.2457	0.1801	0.1421
Indig. oligochaetes	77.33	105.5	133.67	0.1078	0.0790	0.0623

HQ for Mortality NOAEL; TRVs as tissue concentrations (mg/kg wet wt)

also same as HQ for Weight Loss NOAEL

use *L. variegatus* TRV for *C. tentans*

TRVs from USEPA Hudson ERA

Organism	Mortality NOAEL - 1SD	Mortality NOAEL Mean	Mortality NOAEL + 1SD	HQ _{mortality-N, low}	HQ _{mortality-N, mea}	HQ _{mortality-N, high}
<i>L. variegatus</i>	50.56	59.13	67.7	0.0047	0.0040	0.0035
<i>L. variegatus</i>	50.56	59.13	67.7	0.0041	0.0035	0.0030
<i>L. variegatus</i>	50.56	59.13	67.7	0.0005	0.0004	0.0004
<i>L. variegatus</i>	50.56	59.13	67.7	0.0134	0.0114	0.0100
<i>L. variegatus</i>	50.56	59.13	67.7	0.0049	0.0042	0.0037
<i>L. variegatus</i>	50.56	59.13	67.7	0.0070	0.0060	0.0052
<i>L. variegatus</i>	50.56	59.13	67.7	0.8318	0.7112	0.6212
<i>L. variegatus</i>	50.56	59.13	67.7	0.0106	0.0091	0.0079
<i>L. variegatus</i>	50.56	59.13	67.7	0.0006	0.0005	0.0005
<i>L. variegatus</i>	50.56	59.13	67.7	0.0021	0.0018	0.0015
<i>L. variegatus</i>	50.56	59.13	67.7	0.0068	0.0058	0.0051
<i>L. variegatus</i>	50.56	59.13	67.7	0.0011	0.0010	0.0009
<i>L. variegatus</i>	50.56	59.13	67.7	0.0025	0.0021	0.0019
<i>L. variegatus</i>	50.56	59.13	67.7	0.0020	0.0017	0.0015

Appendix 6

<i>L. variegatus</i>	50.56	59.13	67.7	0.0053	0.0045	0.0039
<i>L. variegatus</i>	50.56	59.13	67.7	0.0021	0.0018	0.0016
<i>C. tentans</i>	50.56	59.13	67.7	0.0019	0.0016	0.0014
<i>C. tentans</i>	50.56	59.13	67.7	0.1471	0.1257	0.1098
<i>L. variegatus</i>	50.56	59.13	67.7	0.3758	0.3213	0.2806
Indig. oligochaetes	50.56	59.13	67.7	0.1648	0.1409	0.1231

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Appendix 7: Dicks Creek ERA
HQs for estimated exposures to mayflies

$$HQ = EEL/TRV$$

HQ = Ecological screening quotient

EEL = Expected ecological level (mass COPC/mass body or mass COPC/mass body/d)

TRV = Toxicity reference value (mass COPC/mass body or mass COPC/mass body/d)

HQs calculated using estimated tissue levels of PCBs in mayfly (WSU ERA)

Tissue concentration = EEL

Organism	Year	Model Used to Estimate Tissue Conc.	Site on Dicks Creek	Tissue Concentration (ng/g wet wt)	Tissue Concentration (mg/kg wet wt)	Mortality LOAEL HQ		Mortality NOAEL HQ	
Mayfly	2000	Thomann	Amanda	4.600	0.0046	0.0000	mean	0.0001	mean
Mayfly	2000	Thomann	Amanda	25.300	0.0253	0.0002	0.0005	0.0004	0.0009
Mayfly	2000	Thomann	Amanda	138.600	0.1386	0.0013	stdev 0.0007	0.0023	stdev 0.0012
Mayfly	1999	Thomann	Amanda	14.610	0.0146	0.0001	mean	0.0002	mean
Mayfly	1999	Thomann	Amanda	80.380	0.0804	0.0008	0.0017	0.0014	0.0030
Mayfly	1999	Thomann	Amanda	440.330	0.4403	0.0042	stdev 0.0022	0.0074	stdev 0.0039
Mayfly	2000	Toxicokinetic	Amanda	339.000	0.3390	0.0032	mean	0.0057	mean
Mayfly	2000	Toxicokinetic	Amanda	1508.000	1.5080	0.0143	0.0211	0.0255	0.0376
Mayfly	2000	Toxicokinetic	Amanda	4826.000	4.8260	0.0457	stdev 0.0221	0.0816	stdev 0.0394
Mayfly	1999	Toxicokinetic	Amanda	1077.000	1.0770	0.0102	mean	0.0182	mean
Mayfly	1999	Toxicokinetic	Amanda	4791.000	4.7910	0.0454	0.0670	0.0810	0.1195
Mayfly	1999	Toxicokinetic	Amanda	15332.000	15.3320	0.1453	stdev 0.0701	0.2593	stdev 0.1251
Mayfly	2000	BAF-based	Amanda	9.219	0.0092	0.0001	mean	0.0002	mean
Mayfly	2000	BAF-based	Amanda	251.500	0.2515	0.0024	0.0012	0.0043	0.0022

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						stdev 0.0016	stdev 0.0029
Mayfly	1999	BAF-based	Amanda	29.290	0.0293	0.0003 mean	0.0005 mean
Mayfly	1999	BAF-based	Amanda	799.000	0.7990	0.0076 0.0039	0.0135 0.0070
						stdev 0.0052	stdev 0.0092

HQ for Mortality LOAEL; TRVs as tissue concentrations (mg/kg wet wt)

also same as HQ for Weight Loss LOAEL

use *L. variegatus* TRV for Mayfly

TRVs from USEPA Hudson ERA

Organism	Mortality LOAEL - 1SD	Mortality LOAEL Mean	Mortality LOAEL + 1SD	HQ _{mortality-L, low}	HQ _{mortality-L, mea}	HQ _{mortality-L, high}
Mayfly	77.33	105.5	133.67	0.0001	0.0000	0.0000
Mayfly	77.33	105.5	133.67	0.0003	0.0002	0.0002
Mayfly	77.33	105.5	133.67	0.0018	0.0013	0.0010
Mayfly	77.33	105.5	133.67	0.0002	0.0001	0.0001
Mayfly	77.33	105.5	133.67	0.0010	0.0008	0.0006
Mayfly	77.33	105.5	133.67	0.0057	0.0042	0.0033
Mayfly	77.33	105.5	133.67	0.0044	0.0032	0.0025
Mayfly	77.33	105.5	133.67	0.0195	0.0143	0.0113
Mayfly	77.33	105.5	133.67	0.0624	0.0457	0.0361
Mayfly	77.33	105.5	133.67	0.0139	0.0102	0.0081
Mayfly	77.33	105.5	133.67	0.0620	0.0454	0.0358
Mayfly	77.33	105.5	133.67	0.1983	0.1453	0.1147
Mayfly	77.33	105.5	133.67	0.0001	0.0001	0.0001
Mayfly	77.33	105.5	133.67	0.0033	0.0024	0.0019
Mayfly	77.33	105.5	133.67	0.0004	0.0003	0.0002
Mayfly	77.33	105.5	133.67	0.0103	0.0076	0.0060

Appendix 7

HQ for Mortality NOAEL; TRVs as tissue concentrations (mg/kg wet wt)

also same as HQ for Weight Loss NOAEL

use *L. variegatus* TRV for Mayfly

TRVs from USEPA Hudson ERA

Organism	Mortality NOAEL - 1SD	Mortality NOAEL Mean	Mortality NOAEL + 1SD	HQ _{mortality-N, low}	HQ _{mortality-N, mean}	HQ _{mortality-N, high}
Mayfly	50.56	59.13	67.7	0.0001	0.0001	0.0001
Mayfly	50.56	59.13	67.7	0.0005	0.0004	0.0004
Mayfly	50.56	59.13	67.7	0.0027	0.0023	0.0020
Mayfly	50.56	59.13	67.7	0.0003	0.0002	0.0002
Mayfly	50.56	59.13	67.7	0.0016	0.0014	0.0012
Mayfly	50.56	59.13	67.7	0.0087	0.0074	0.0065
Mayfly	50.56	59.13	67.7	0.0067	0.0057	0.0050
Mayfly	50.56	59.13	67.7	0.0298	0.0255	0.0223
Mayfly	50.56	59.13	67.7	0.0955	0.0816	0.0713
Mayfly	50.56	59.13	67.7	0.0213	0.0182	0.0159
Mayfly	50.56	59.13	67.7	0.0948	0.0810	0.0708
Mayfly	50.56	59.13	67.7	0.3032	0.2593	0.2265
Mayfly	50.56	59.13	67.7	0.0002	0.0002	0.0001
Mayfly	50.56	59.13	67.7	0.0050	0.0043	0.0037
Mayfly	50.56	59.13	67.7	0.0006	0.0005	0.0004
Mayfly	50.56	59.13	67.7	0.0158	0.0135	0.0118

Appendix 7: Dicks Creek ERA
HQS for demersal fish

HQ from TRVs in USEPA Hudson River ERA, Table 4-25
TRVs are for the brown bullhead (*Ictalurus nebulosus*)
Used OEPA fish data for EECs

Lab-based TRV for PCBs 17 mg/kg wet wt
Field-based TRV for PCBs 1.5

Species	Lab-based HQ	Field-based HQ
Channel Cat	0.036	0.413
Channel Cat	0.018	0.205
Carp	0.013	0.147
Carp	1.559	17.667
Carp	0.109	1.240
White Sucker	0.246	2.793
White Sucker	0.107	1.213
mean	0.298	3.383
stdev	0.562	6.355

HQ from TRVs in USEPA Hudson River ERA, Table 4-3
TRVs are for complete mortality (LD100) of 2 fish species
Used OEPA fish data for EECs

Lab-based LD100 for PCBs in Lake Trout Fry 7.6 mg/kg wet wt
Lab-based LD100 for PCBs in Chinook Salmon 3.6 mg/kg wet wt

Species	Lake Trout Fry	Chinook Salmon Fry
Channel Cat	0.082	0.172
Channel Cat	0.040	0.085
Carp	0.029	0.061
Carp	3.487	7.361
Carp	0.245	0.517
White Sucker	0.551	1.164
White Sucker	0.239	0.506
mean	0.668	1.409
stdev	1.256	2.652

HQ for various toxicity endpoints; TRVs as tissue concentrations (mg/kg wet wt)

Used OEPA fish data for EECs

TRVs from USEPA Hudson ERA, Table 4-3

HQ from Mortality LOAEL for all PCBs			
	HQ from lowest TRV	HQ from mean TRV	HQ from highest TRV
	0.1378	0.0030	0.0006
	0.0682	0.0015	0.0003
	0.0489	0.0011	0.0002
	5.8889	0.1287	0.0265
	0.4133	0.0090	0.0019
	0.9311	0.0203	0.0042
	0.4044	0.0088	0.0018
mean	1.1275	0.0246	0.0051
stdev	2.1216	0.0464	0.0096

HQ from Mortality LOAEL for Aroclor 1254			
	HQ from lowest TRV	HQ from mean TRV	HQ from highest TRV
	0.1378	0.0021	0.0006
	0.0682	0.0010	0.0003
	0.0489	0.0007	0.0002
	5.8889	0.0902	0.0265
	0.4133	0.0063	0.0019
	0.9311	0.0143	0.0042
	0.4044	0.0062	0.0018
mean	1.1275	0.0173	0.0051
stdev	2.1216	0.0325	0.0096

HQ from Mortality NOAEL for all PCBs			
	HQ from lowest TRV	HQ from mean TRV	HQ from highest TRV
	0.1632	0.0044	0.0014
	0.0808	0.0022	0.0007
	0.0579	0.0015	0.0005
	6.9737	0.1872	0.0608
	0.4895	0.0131	0.0043
	1.1026	0.0296	0.0096
	0.4789	0.0129	0.0042
mean	1.3352	0.0358	0.0116
stdev	2.5124	0.0674	0.0219

HQ from Mortality NOAEL for Aroclor 1254			
	HQ from lowest TRV	HQ from mean TRV	HQ from highest TRV
	0.0230	0.0127	0.0014
	0.0114	0.0063	0.0007
	0.0081	0.0045	0.0005
	0.9815	0.5408	0.0618
	0.0689	0.0380	0.0043
	0.1552	0.0855	0.0098
	0.0674	0.0371	0.0042
mean	0.1879	0.1035	0.0118
stdev	0.3536	0.1948	0.0223

HQ from Reprod. LOAEL for all PCBs			
	HQ from lowest TRV	HQ from mean TRV	HQ from highest TRV
	0.1632	0.0043	0.0014
	0.0808	0.0022	0.0007
	0.0579	0.0015	0.0005
	6.9737	0.1857	0.0618
	0.4895	0.0130	0.0043
	1.1026	0.0294	0.0098
	0.4789	0.0128	0.0042
mean	1.3352	0.0356	0.0118
stdev	2.5124	0.0669	0.0223

HQ from Reprod. LOAEL for Aroclor 1254			
	HQ from lowest TRV	HQ from mean TRV	HQ from highest TRV
	0.1378	0.0034	0.0014
	0.0682	0.0017	0.0007
	0.0489	0.0012	0.0005
	5.8889	0.1473	0.0618
	0.4133	0.0103	0.0043
	0.9311	0.0233	0.0098
	0.4044	0.0101	0.0042
mean	1.1275	0.0282	0.0118
stdev	2.1216	0.0531	0.0223

HQ from Reprod. NOAEL for all PCBs			
	HQ from lowest TRV	HQ from mean TRV	HQ from highest TRV
	0.8158	0.0045	0.0014
	0.4039	0.0022	0.0007
	0.2895	0.0016	0.0005
	34.8684	0.1928	0.0618
	2.4474	0.0136	0.0043
	5.5132	0.0305	0.0098
	2.3947	0.0132	0.0042
mean	6.6761	0.0369	0.0118
stdev	12.5621	0.0695	0.0223

HQ from Reprod. NOAEL for Aroclor 1254			
	HQ from lowest TRV	HQ from mean TRV	HQ from highest TRV
	0.0087	0.0023	0.0014
	0.0043	0.0011	0.0007
	0.0031	0.0008	0.0005
	0.3732	0.0993	0.0618
	0.0262	0.0070	0.0043
	0.0590	0.0157	0.0098
	0.0266	0.0066	0.0042
mean	0.0715	0.0190	0.0118
stdev	0.1345	0.0358	0.0223

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Appendix 8: Dicks Creek ERA

HQs for demersal fish

$$HQ = EEL/TRV$$

HQ = Ecological screening quotient

EEL = Expected ecological level (mass COPC/mass body or mass COPC/mass body/d)

TRV = Toxicity reference value (mass COPC/mass body or mass COPC/mass body/d)

HQs calculated using fish tissue data from OEPA

Tissue concentration = EEL

OEPA fish data from Dicks Creek (demersal species only)

Year	Species	Total PCBs (mg/kg)
1996	Channel Cat	0.62
1998	Channel Cat	0.307
1996	Carp	0.22
1998	Carp	26.5
1998	Carp	1.86
1998	White Sucker	4.19
1998	White Sucker	1.82

HQ from TRVs in USEPA Hudson River ERA, Table 4-25

These TRVs are for the brown bullhead (*Ictalurus nebulosus*), a catfish

Used OEPA fish data for EECs

Lab-based TRV for PCBs 17 mg/kg wet wt

Field-based TRV for PCBs 1.5

Appendix 8

Species	Lab-based	Field-based
	HQ	HQ
Channel Cat	0.036	0.413
Channel Cat	0.018	0.205
Carp	0.013	0.147
Carp	1.559	17.667
Carp	0.109	1.240
White Sucker	0.246	2.793
White Sucker	0.107	1.213
<i>mean</i>	0.298	3.383
<i>stdev</i>	0.562	6.365

HQ from TRVs in USEPA Hudson River ERA, Table 4-3
 These TRVs are for complete morality (LD₁₀₀) of 2 fish species
 Used OEPA fish data for EECs

Lab-based LD₁₀₀ for PCBs in Lake Trout Fry 7.6 mg/kg wet wt
 Lab-based LD₁₀₀ for PCBs in Chinook Salmon Fry 3.6 mg/kg wet wt.

Species	Lake Trout	Chinook
	Fry	Salmon Fry
Channel Cat	0.082	0.172
Channel Cat	0.040	0.085
Carp	0.029	0.061
Carp	3.487	7.361
Carp	0.245	0.517
White Sucker	0.551	1.164
White Sucker	0.239	0.506
<i>mean</i>	0.668	1.409
<i>stdev</i>	1.256	2.652

Appendix 8

HQ for various toxicity endpoints; TRVs as tissue concentrations (mg/kg wet wt)

Used OEPA fish data for EECs

TRVs from USEPA Hudson ERA, Table 4-3

				HQ from Mortality LOAEL for all PCBs		
Organism	Mortality LOAEL lowest	Mortality LOAEL Mean	Mortality LOAEL highest	HQ from lowest TRV	HQ from mean TRV	HQ from highest TRV
Channel Cat	4.5	205.92	999.00	0.1378	0.0030	0.0006
Channel Cat	4.5	205.92	999.00	0.0682	0.0015	0.0003
Carp	4.5	205.92	999.00	0.0489	0.0011	0.0002
Carp	4.5	205.92	999.00	5.8889	0.1287	0.0265
Carp	4.5	205.92	999.00	0.4133	0.0090	0.0019
White Sucker	4.5	205.92	999.00	0.9311	0.0203	0.0042
White Sucker	4.5	205.92	999.00	0.4044	0.0088	0.0018
				<i>mean</i>	1.1275	0.0246
				<i>stdev</i>	2.1216	0.0464
						0.0051
						0.0096

				HQ from Mortality NOAEL for all PCBs		
Organism	Mortality NOAEL lowest	Mortality NOAEL Mean	Mortality NOAEL highest	HQ from lowest TRV	HQ from mean TRV	HQ from highest TRV
Channel Cat	3.8	141.56	436.00	0.1632	0.0044	0.0014
Channel Cat	3.8	141.56	436.00	0.0808	0.0022	0.0007
Carp	3.8	141.56	436.00	0.0579	0.0016	0.0005
Carp	3.8	141.56	436.00	6.9737	0.1872	0.0608
Carp	3.8	141.56	436.00	0.4895	0.0131	0.0043
White Sucker	3.8	141.56	436.00	1.1026	0.0296	0.0096
White Sucker	3.8	141.56	436.00	0.4789	0.0129	0.0042
				<i>mean</i>	1.3352	0.0358
						0.0116

Appendix 8

stdev 2.5124 0.0674 0.0219

HQ from Reprod. LOAEL for all PCBs

Organism	Reprod. LOAEL lowest	Reprod. LOAEL Mean	Reprod. LOAEL highest	HQ from lowest TRV	HQ from mean TRV	HQ from highest TRV
Channel Cat	3.8	142.70	429.00	0.1632	0.0043	0.0014
Channel Cat	3.8	142.70	429.00	0.0808	0.0022	0.0007
Carp	3.8	142.70	429.00	0.0579	0.0015	0.0005
Carp	3.8	142.70	429.00	6.9737	0.1857	0.0618
Carp	3.8	142.70	429.00	0.4895	0.0130	0.0043
White Sucker	3.8	142.70	429.00	1.1026	0.0294	0.0098
White Sucker	3.8	142.70	429.00	0.4789	0.0128	0.0042
				mean	1.3352	0.0356
				stdev	2.5124	0.0669
						0.0118
						0.0223

HQ from Reprod. NOAEL for all PCBs

Organism	Reprod. NOAEL lowest	Reprod. NOAEL Mean	Reprod. NOAEL highest	HQ from lowest TRV	HQ from mean TRV	HQ from highest TRV
Channel Cat	0.76	137.44	429.00	0.8158	0.0045	0.0014
Channel Cat	0.76	137.44	429.00	0.4039	0.0022	0.0007
Carp	0.76	137.44	429.00	0.2895	0.0016	0.0005
Carp	0.76	137.44	429.00	34.8684	0.1928	0.0618
Carp	0.76	137.44	429.00	2.4474	0.0135	0.0043
White Sucker	0.76	137.44	429.00	5.5132	0.0305	0.0098
White Sucker	0.76	137.44	429.00	2.3947	0.0132	0.0042
				mean	6.6761	0.0369
				stdev	12.5621	0.0695
						0.0118
						0.0223

Appendix 8

Organism	Aroclor 1254 Mortality LOAEL	Aroclor 1254 Mortality LOAEL	Aroclor 1254 Mortality LOAEL	<u>HQ from Mortality LOAEL for Aroclor 1254</u>		
	lowest	Mean	highest	HQ from lowest TRV	HQ from mean TRV	HQ from highest TRV
Channel Cat	4.5	293.63	999.00	0.1378	0.0021	0.0006
Channel Cat	4.5	293.63	999.00	0.0682	0.0010	0.0003
Carp	4.5	293.63	999.00	0.0489	0.0007	0.0002
Carp	4.5	293.63	999.00	5.8889	0.0902	0.0265
Carp	4.5	293.63	999.00	0.4133	0.0063	0.0019
White Sucker	4.5	293.63	999.00	0.9311	0.0143	0.0042
White Sucker	4.5	293.63	999.00	0.4044	0.0062	0.0018
				<i>mean</i>	1.1275	0.0173
				<i>stdev</i>	2.1216	0.0325

Organism	Aroclor 1254 Mortality NOAEL	Aroclor 1254 Mortality NOAEL	Aroclor 1254 Mortality NOAEL	<u>HQ from Mortality NOAEL for Aroclor 1254</u>		
	lowest	Mean	highest	HQ from lowest TRV	HQ from mean TRV	HQ from highest TRV
Channel Cat	27	49.00	429.00	0.0230	0.0127	0.0014
Channel Cat	27	49.00	429.00	0.0114	0.0063	0.0007
Carp	27	49.00	429.00	0.0081	0.0045	0.0005
Carp	27	49.00	429.00	0.9815	0.5408	0.0618
Carp	27	49.00	429.00	0.0689	0.0380	0.0043
White Sucker	27	49.00	429.00	0.1552	0.0855	0.0098
White Sucker	27	49.00	429.00	0.0674	0.0371	0.0042
				<i>mean</i>	0.1879	0.1035
				<i>stdev</i>	0.3536	0.1948

Aroclor 1254	Aroclor 1254	Aroclor 1254	<u>HQ from Reprod. LOAEL for Aroclor 1254</u>
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Appendix 8

Organism	Reprod. LOAEL lowest	Reprod. LOAEL Mean	Reprod. LOAEL highest	HQ from lowest TRV	HQ from mean TRV	HQ from highest TRV
Channel Cat	4.5	179.90	429.00	0.1378	0.0034	0.0014
Channel Cat	4.5	179.90	429.00	0.0682	0.0017	0.0007
Carp	4.5	179.90	429.00	0.0489	0.0012	0.0005
Carp	4.5	179.90	429.00	5.8889	0.1473	0.0618
Carp	4.5	179.90	429.00	0.4133	0.0103	0.0043
White Sucker	4.5	179.90	429.00	0.9311	0.0233	0.0098
White Sucker	4.5	179.90	429.00	0.4044	0.0101	0.0042
<i>mean</i>				1.1275	0.0282	0.0118
<i>stdev</i>				2.1216	0.0531	0.0223

Organism	Aroclor 1254 Reprod. NOAEL lowest	Aroclor 1254 Reprod. NOAEL Mean	Aroclor 1254 Reprod. NOAEL highest	HQ from Reprod. NOAEL for Aroclor 1254		
				HQ from lowest TRV	HQ from mean TRV	HQ from highest TRV
Channel Cat	71	267.00	429.00	0.0087	0.0023	0.0014
Channel Cat	71	267.00	429.00	0.0043	0.0011	0.0007
Carp	71	267.00	429.00	0.0031	0.0008	0.0005
Carp	71	267.00	429.00	0.3732	0.0993	0.0618
Carp	71	267.00	429.00	0.0262	0.0070	0.0043
White Sucker	71	267.00	429.00	0.0590	0.0157	0.0098
White Sucker	71	267.00	429.00	0.0256	0.0068	0.0042
<i>mean</i>				0.0715	0.0190	0.0118
<i>stdev</i>				0.1345	0.0358	0.0223

Appendix 9: Dicks Creek ERA
HQs for estimated exposures to belted kingfisher

HQ = EEL/TRV

HQ = Ecological screening quotient

EEL = Expected ecological level (mass COPC/mass body or mass COPC/mass body/d)

TRV = Toxicity reference value (mass COPC/mass body or mass COPC/mass body/d)

HQs calculated using estimated daily dose levels of PCBs to belted kingfisher (WSU ERA)

For WSU ERA calculations, OEPA fish data was the input for contaminated food

Tissue concentration = EEL

Organism	Model Used to Estimate Daily Dose	% Food Contaminated in Model	Estimate	Dietary Dose (mg/kg/d)	Hudson NOAEL-TRV-based HQ	Hudson LOAEL-TRV-based HQ	Oak Ridge NOAEL-TRV-based HQ for Aroclor 1242	Oak Ridge NOAEL-TRV-based HQ for Aroclor 1254	Oak Ridge LOAEL-TRV-based HQ for Aroclor 1254	HQ _{reprod-L} , mean	HQ _{reprod-N} , mean
<i>Belted kingfisher</i>	SLERAP-FCM	100	lowest	0.09	9.46	1.35	0.23	0.53	0.05	0.0657	0.0553
<i>Belted kingfisher</i>	SLERAP-FCM	100	highest	39.90	3990.00	570.00	97.32	221.67	22.17	27.7083	23.3333
<i>Belted kingfisher</i>	SLERAP-FCM	50	lowest	0.05	4.70	0.67	0.11	0.26	0.03	0.0326	0.0275
<i>Belted kingfisher</i>	SLERAP-FCM	50	highest	19.90	1990.00	284.29	48.54	110.56	11.06	13.8194	11.6374
<i>Belted kingfisher</i>	SLERAP-FCM	10	lowest	0.01	0.95	0.14	0.02	0.05	0.01	0.0066	0.0056
<i>Belted kingfisher</i>	SLERAP-FCM	10	highest	3.99	399.00	57.00	9.73	22.17	2.22	2.7708	2.3333

HQ from TRVs in USEPA Hudson River ERA, Table 4-25 and Oak Ridge wildfile document (tm86r3.pdf)

These TRVs are for the brown bullhead (*Ictalurus nebulosus*), a catfish

Used OEPA fish data for EECs

Lab-based NOAEL-TRV for PCBs in belted kingfisher (Hudson document)	0.01 mg/kg/d
Lab-based LOAEL-TRV for PCBs in belted kingfisher (Hudson document)	0.07 mg/kg/d
Belted kingfisher NOAEL-based benchmark for Aroclor 1242 (Oak Ridge)	0.41 mg/kg/d
Belted kingfisher NOAEL-based benchmark for Aroclor 1254 (Oak Ridge)	0.18 mg/kg/d
Belted kingfisher LOAEL-based benchmark for Aroclor 1254 (Oak Ridge)	1.8 mg/kg/d

Dietary Dose (mg/kg/d) (from above)	Hudson NOAEL-TRV	Hudson LOAEL-TRV	Oak Ridge NOAEL-TRV for Aroclor 1242	Oak Ridge NOAEL-TRV for Aroclor 1254	Oak Ridge LOAEL-TRV for Aroclor 1254
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AK5 041799

Appendix 9

0.095	9.460	1.351	0.230731707	0.525555556	0.052555556
39.900	3990.000	570.000	97.31707317	221.6666667	22.16666667
0.047	4.700	0.671	0.114634146	0.261111111	0.026111111
19.900	1990.000	284.286	48.53658537	110.5555556	11.05555556
0.010	0.950	0.136	0.023170732	0.052777778	0.005277778
3.990	399.000	57.000	9.731707317	22.16666667	2.216666667
mean					
stdev					

← These values are for only 10% of dietary contamination from Dicks Creek

HQ for Reproductive Effects LOAEL; TRVs as dietary doses (mg/kg/d)

use bird toxicity data and TRVs for kingfisher
TRVs from USEPA Hudson ERA

Organism	Reprod LOAEL - 1SD	Reprod LOAEL Mean	Reprod LOAEL + 1SD	HQ _{reprod-L} , low	HQ _{reprod-L} , mean	HQ _{reprod-L} , high
<i>Belted kingfisher</i>	0.54	1.44	2.34	0.1752	0.0657	0.0404
<i>Belted kingfisher</i>	0.54	1.44	2.34	73.8889	27.7083	17.0513
<i>Belted kingfisher</i>	0.54	1.44	2.34	0.0870	0.0326	0.0201
<i>Belted kingfisher</i>	0.54	1.44	2.34	36.8519	13.8194	8.5043
<i>Belted kingfisher</i>	0.54	1.44	2.34	0.0176	0.0066	0.0041
<i>Belted kingfisher</i>	0.54	1.44	2.34	7.3889	2.7708	1.7051

HQ for Reproductive Effects NOAEL; TRVs as dietary doses (mg/kg/d)

use bird toxicity data and TRVs for kingfisher
TRVs from USEPA Hudson ERA

Organism	Mortality NOAEL - 1SD	Mortality NOAEL Mean	Mortality NOAEL + 1SD	HQ _{reprod-N} , low	HQ _{reprod-N} , mean	HQ _{reprod-N} , high
<i>Belted kingfisher</i>	0.1	1.71	5.15	0.9460	0.0553	0.0184
<i>Belted kingfisher</i>	0.1	1.71	5.15	399.0000	23.3333	7.7476
<i>Belted kingfisher</i>	0.1	1.71	5.15	0.4700	0.0275	0.0091
<i>Belted kingfisher</i>	0.1	1.71	5.15	199.0000	11.6374	3.8641
<i>Belted kingfisher</i>	0.1	1.71	5.15	0.0950	0.0056	0.0018
<i>Belted kingfisher</i>	0.1	1.71	5.15	39.9000	2.3333	0.7748

AK5 041800

Appendix B

Site Description

AK5 041801

Overview

The City of Middletown has a population of 55,000 and is located approximately 30 miles south of downtown Dayton and approximately 45 miles north of downtown Cincinnati (Figure 1). AK Steel, the city's largest employer, produces flat rolled steel and intermediate products of pig iron and coke in addition to steel finishing and coating.

The main branch of Dicks Creek, a tributary of the lower Great Miami River basin, is a 10.5 mile first order stream draining 47.6 mi² in Warren and Butler counties. The headwaters are located in southeastern Warren county near Manchester Road.

Study sites on Dicks Creek in the Middletown, Ohio area were chosen on the basis of either historic sediment contamination levels or proximity to known point source areas of concern (e.g., AK Steel outfalls) (Figure 2). Between 1996 and 2000, a total of seven test sites (five on Dicks Creek and two reference sites) have been evaluated by researchers at Wright State University's Institute for Environmental Quality for potential toxicity via both laboratory (EPA and non-EPA test methods) and field (*in situ*) studies. *In situ* and laboratory toxicity tests have been focused in the following locations in and around the main AK Steel facility on the main branch of Dicks Creek running parallel to Oxford State Road.

1) The confluence site (Rm 5.26), is located at the confluence of the North and main branches of Dicks Creek at the intersection of Briel and Oxford State Roads directly downstream of Moraine Materials (ready mix concrete manufacturer). This area is flanked by mowed grassy areas with no riparian zone. Surficial sediments at this site consist of coarse sand and pebbles, often containing precipitates and frequently larger depositional areas of calcium carbonate discharged as washout by Moraine Materials, just upstream of the confluence. The main branch of Dicks Creek above this point is typically dry during low flow conditions.

2) AK Steel outfall 003 (Rm 4.81) is located on the main branch of Dicks Creek south of the confluence, directly across the street from AK Steel's south plant. Outfall 003 is a continuous flow discharge. Both banks are controlled grassy areas and are steep to gently sloping. The south bank has a rich riparian zone approximately 40 meters beyond the grass area.

Several migratory and resident bird species have been observed to frequent this area. Sediments in this area are generally coarse sand and pebbles.

3) AK Steel outfall 002 (Rm 3.93) is located directly across the street from the AK Steel Coke plant facility and directly behind 4 Aces, a privately owned business. Outfall 002 is a continuous flow discharge. The creek banks are gently sloping and covered with a meadow of grasses and wildflowers. The north bank is flanked by a privately owned business and the south bank has a fordable riparian zone approximately 20 meters beyond the meadow area. Sediments in and around this area are pebbly to rocky with a few small sandy depositional areas along the north bank. Tufts of macrophytes have been frequently observed here. Several migratory and resident bird species have been observed to frequent this area.

4) The Landfill tributary sites (~Rm 2.71) area located in the mouth area of the unnamed tributary that flows south to north through agricultural areas entering the main branch of Dicks Creek just north (upstream) of Yankee Road. This tributary has also been called the "Monroe drainage ditch". Landfill(s) adjacent to this tributary, are believed to contain improperly stored polychlorinated biphenyls (PCBs) that have ultimately leached from seeps in the landfill into the surrounding soils and sediments. PCBs emanating from these seeps are believed to be the principal source of contamination to this system. The leached PCBs adhere to the fine particulate sediments and slowly wash into the system, acting as a constant source of contamination. The highest concentrations of PCBs measured in Dicks Creek have come from sediments and organisms collected from the landfill tributary area.

5) The USGS site (~Rm 2.45) is located in and around the USGS gauging station positioned just west of the Yankee Road bridge. Various locations in and around this area (+/- 100M to either side the USGS gauging station) and have been used within this 200 M stretch based upon accessibility and bottom sediment consistency. The banks on either side are gently sloping and are characterized by mowed grass to approximately five meters of the creek. The five meters adjacent to the creek are tall grasses and wildflowers. The creek width doubles in size in this area and sediments tend to be areas of shifting sand and pebbles. Patchy pockets of oil have been observed in the sediments at this site. A few species of frogs and turtles have been observed at this site. Children are often observed swimming and fishing in this area. Just beyond the gauging station, both banks of Dicks Creek are flanked by rich riparian zones of

depths of up to 100 meters. From the confluence site to the USGS gauging station, the creek is very channelized with little meadow or riparian protection.

6) Amanda School site (~Rm 1.63) is located behind Amanda Middle School on privately owned property. Both stream banks steep are characterized by dense riparian zones extending directly to the water line. Children are often observed playing and swimming in this area. Sediments at this site consists predominantly of pebbles, gravel, and rocks, however, sandy depositional zones can be found along the southern bank. At this site, an unnamed tributary and a semi-active outfall enter the main branch from the south.

Field reference sites included: 1) Elk creek, a tributary of the Lower Great Miami River (Rm 49.80), located just northwest of Middletown in the adjacent rural area of Madison Township (~Rm 3.7) (Figure 3). Elk Creek was chosen as it is in the same watershed yet outside of the influence of AK Steel. Elk Creek is also considered a clean reference site by OEPA.

Sediments in this creek range from small sandy patches to large boulders. The creek is flanked by a moderate riparian zone on both banks, however, in upper regions meanders through large agricultural regions (farming and cattle grazing) and is believed receive a fair amount of agricultural runoff indicated by the presence of large algal blooms in the spring and fall. 2) Little Sugar Creek located in Beavercreek, Ohio (Figure 4).

Organisms observed living in or near the Dicks Creek have included invertebrates, fish, amphibians, birds, mammals and several plant species. All of these organisms may be directly exposed to the PCBs from contaminated sediments, river water, and air, and/or indirectly exposed through ingestion of food (e.g., prey) containing PCBs. Humans have been frequent observed swimming, fishing and wading in and around the creek. Humans have been directly exposed to water, sediment and contaminated fish (fish filets have been observed on the banks of the creek).

Toxicity tests in the laboratory were conducted on sediment and water samples from all of the aforementioned sites with the exception AK Steel outfalls 003 and 002. For QA/QC purposes, toxicity testing at field reference sites test accompanied each field and laboratory study.

AK5 041804

Appendix C

Field Exposures

AK5 041805

***In situ* Chamber Construction**

The *in situ* chambers used for both the survival and bioaccumulation studies with the standard EPA approved organisms were constructed of clear core sampling tubes (cellulose acetate butyrate) cut to a length of approximately 13 cm (volume ~ 435 mLs). Polyethylene closures capped each end. Two rectangular windows (~85% of the core surface area) covered with 80 μ m Nitex® mesh were placed on opposite sides of the core tube (Figure 24).

Exposure Design

For the survival and short term bioaccumulation studies (1998-2000), organism exposures were limited to: (1) WC - the water column, via placement of the chamber in the top tray of the *in situ* basket, (2) AS - interaction with both sediments and overlying water via placement of the chamber against the sediment surface by securing it to the lower *in situ* basket with one window facing the sediment and one mesh window facing the overlying water column (Figure 25), (3) SS - in the sediment, via filling chambers approximately one-third with sediment and the rest with overlying water and (4) PWC - pore (interstitial) water exposure only by completely burying chambers in the sediments to the bottom of the inlet/outlet tubes (Figure 26).

In situ baskets were weighted down with bricks and anchored to the stream bottom with rebar. Each set of baskets was covered by a stainless steel flow deflector designed to divert strong currents of water and turbulence around the *in situ* chambers should a high flow event have occurred during exposure (Figure 25). The functional design of the flow deflector prevents the baskets from being swept away during short periods of high flow conditions. Surficial sediment (SS) and Pore water (PWC) exposures chambers were deployed in the field 48-96 h prior to organism addition in order to reach an equilibrated state the surrounding environment. Research study goals were designed around exposure time and compartment in order to most effectively pinpoint the most critical route(s) of exposure.

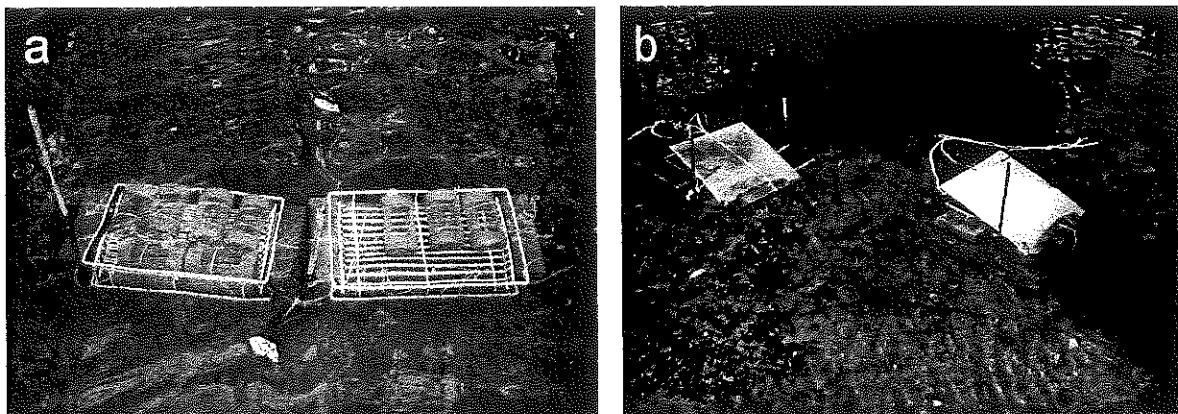


Figure 25: a) *In situ* chambers deployed in wire baskets and b) *in situ* chambers/baskets protected with flow deflectors.

Test Organisms

Laboratory surrogate test organisms utilized for survival included: the daphnia, *Daphnia magna* (48 hr), the fathead minnow, *Pimephales promelas* (48 hr), the midge, *Chironomus tentans* (5-10d), the amphipod, *Hyaella azteca* (5-10d) and for bioaccumulation potential, the oligochaete, *Lumbriculus variegatus* (5-10d). All treatments were conducted in replicates of four chambers per organism with ten organisms per chamber (40/treatment). In most cases, organisms were paired and placed in chambers together to allow for more manageable treatment exposures in the field. Treatment pairs included: *H. azteca* and *C. tentans* together in a chamber, *D. magna* and *P. promelas* together and *L. variegatus* alone. The Asiatic clam, *Corbicula fluminea* and the mayfly, *Hexigenia limbata*, were also used by Wright State researchers for *in situ* toxicity testing at Dicks Creek.

Deployment and Retrieval of Chambers

Prior to chamber deployment, in the laboratory, ten of each organism (*H. azteca*, *C. tentans*, *P. promelas* and *D. magna*) were gently added to 50 mL test tubes of culture water for ease of transport to field locations (one test tube contained one species only). Transportation of organisms to field sites by this method has proven to minimize handling and travel related stressors. For the 7-d *L. variegatus* bioaccumulation assay, 1 g of tissue was used in each chamber. In the field, site water temperatures were measured and additional acclimation took place in the field when necessary.

Upon acclimation, *in situ* chambers capped on one end were immersed into the river allowing water to fill the chamber by infiltration through the mesh and test organisms were slowly delivered from the test tubes into the open end the chambers then capped or through inlet tubes on SS and PWC chambers. Before placement into *in situ* baskets, chambers were held below the water surface and purged of all internal air.

After 2-10 days of exposure, *in situ* chambers were gently lifted out of the river and either placed into coolers of site water for the return trip to the Wright State laboratory for enumeration (1998-99) or enumerated in the field (2000). In the laboratory and/or in the field, chambers were inspected for damage, rinsed on the outside and individually emptied into crystallizing dishes. The survivors of each species were enumerated and logged.

Long term (48 h – 28d) tissue bioaccumulation studies (1996-1998), utilized the same basic chamber design however with a modified deployment protocol and exposure compartment. *In situ* chambers capped on one end were gently inserted, open end down (core sample fashion), vertically into the stream bottom to a depth of approximately 8 cm (Figure 27). During deployment, care was taken prevent perturbation to sediment integrity as possible. As mention previously, in the laboratory, organisms were added to 50 mL test tubes of culture water and slowly acclimated during transportation to field sites. A small porthole was incorporated into each chamber end cap to allow for organism addition directly in the field. To facilitate delivery to the exposure chamber, organisms were transferred from the laboratory prepared test tube into a 50 mL syringe equipped with wide bore pipette. Organisms were gently delivered via the syringe to the inside of the chamber through the porthole, which was subsequently sealed with a Teflon screw. After 48h, 1 wk, 2 wk, 3 wk and 4 wks of exposure, four replicates were gently removed from the stream bed, capped on the open end and transported back to the laboratory in a cooler of site water for depuration and enumeration. Chambers were deployed in replicates of four with 15-20 organisms per chamber for each exposure period.

Appendix D

Laboratory Assays

AK5 041809

Test methods

Laboratory tests for the assessment of sublethal toxicity were conducted on sediments collected from all *in situ* sites on Dicks Creek. The same test species used for *in situ* toxicity testing were also used in laboratory tests following USEPA sediment test method recommendations (USEPA 1994). Tests were designed from year to year to evaluate survival and/or bioaccumulation following either exposure periods recommended by USEPA or exposure periods commensurate with field studies. There are no USEPA sediment test method recommendations for *P. promelas*, *D. magna* or *L. variegatus*, hence testing with these species was conducted following methods developed for *C. tentans* and *H. azteca* (Tables 22-25).

The 10-d sediment toxicity test was conducted at 23°C with a 16:8 hr light:dark photoperiod at an illuminance of 500 to 1000 lux (Tables 22,24). Test chambers were 300-mL high-form lipless beakers containing 100 mL of sediment and 175 mL of overlying water. Three to four replicates, each containing ten, organisms were tested for each sample. Organisms in each test chamber were fed daily rations of either YCT (yeast-cerophyl-trout chow), *Selenastrum capricornutum* (green algae) or TetraFin® (USEPA 1994). Each test chamber received 2 daily volume additions/d of overlying water. Controls sediments accompanied each test consisting of a clean reference site sediment, Ottawa sand and/or a laboratory water.

The day before the sediment test was started (Day -1) each sediment was thoroughly homogenized for five to ten minutes with a stainless steel spoon then added to each pre-labeled test chamber. Overlying water was gently added to each chamber on Day -1 in a manner that minimized suspension of sediment. Organisms were gently introduced into the overlying water below the air-water interface at test initiation (Day 0). Daily, each test chamber received 2 volume additions/d of overlying water and the appropriate food source and volume. All chambers were checked daily and observations made to assess test organism behavior such as sediment avoidance. At the beginning and end of each sediment exposure, overlying water quality was measured for: dissolved oxygen (mg/L), temperature (°C), conductivity (µmhos) hardness (mg/L CaCO₃), alkalinity (mg/L CaCO₃), ammonia (mg/L total ammonia) and pH. Dissolved oxygen was measured daily to ensure that chambers maintained a minimum reading of 2.5 mg/L. Aeration was required to maintain dissolved oxygen in the overlying water above 2.5 mg/L. Temperature was measured daily in at least one test chamber from each treatment. Aquarium heaters were used to maintain water bath temperatures within this range.

At test termination (Day 2), Surviving *D. magna* and *P. promelas* were removed directly from the water column of each replicate beaker with a wide bore pipet and monitored for survival. On days 7-10, sediments from each of the *H. azteca*, *C. tentans* and *L. variegatus* replicate beakers were individually sieved with an ASTM U.S. Standard #45 mesh sieve (355 µm mesh) to remove surviving organisms. *H. azteca* and *C. tentans* were monitored for survival and viable tissues saved for PCB/PAH tissue residues.

For tissue residue analysis, surviving organisms were collected and placed into clean beakers of culture water. The four replicates for each treatment were pooled (*i.e.*, all worms for the 4 replicates were placed into the same beaker of water). Following collection of organisms, any debris was cleared out of the culture water and organisms were allowed to depurate (gut purging) for 6-36 hours. Six hours is the minimum recommended depuration time for *L. variegatus* bioaccumulation studies (Mount, 1999). After the depuration period, overlying water was decanted from the beakers and the tissues were blotted of any excess water using clean paper toweling. The tissue samples were then placed into pre-weighed/pre-labeled 40 mL amber vials and weighed for wet weight determination. Following wet weight analysis, tissues were extracted with dichloromethane and placed in the freezer until being relinquished to Dr. Thomas Tiernan, Wright State University for residue analysis.

Culturing

For all toxicity tests (*i.e.*, laboratory and *in situ* tests), early life stages of test organisms (except *Lumbriculus variegatus* where mixed aged worms were used) were implemented as prescribed. Culturing procedures followed USEPA methods for *Hyaella azteca*, *Chironomus tentans*, *Daphnia magna* and *Lumbriculus variegatus* (USEPA 1994).

Data Analyses

Data meeting assumptions of normality and homogeneity of variance by analysis of variance (ANOVA) were followed up with Dunnett's test. Data not meeting assumptions of normality were analyzed using Steel's many-one rank test (Toxstat®, Version 3.4). Correlation coefficients analyses for all data were determined via Pearson's correlation (Statistica®, Version 5).

Quality Assurance

Protocols for the chronic toxicity test methods were followed as outlined (ASTM 1999, USEPA 1998). Other quality assurance issues are addressed in the Quality Assurance Project Plan for the U.S. Environmental Protection Agency's Freshwater Sediment Toxicity Methods Evaluation (Burton 1997).

All field and laboratory water quality monitoring equipment was calibrated prior to each use according to EPA and/or instrument specifications.

AK5 041812

Appendix E

Sampling Methods

AK5 041813

General

Sediment, water and tissue samples for chemical analyses and laboratory toxicity testing were collected from the seven test site locations by Wright State University researchers following project approved protocols. These methods included standard quality assurance and quality control measures as well as those gleaned from current scientific literature in order to ensure that the sediment samples were not significantly altered and that cross contamination did not occur (ASTM 1999; Burton 1997; USEPA 1991a, 1991b, 1994, 1998, 1999). Proper sample labeling and chain-of-custody procedures were followed. All samples were either preserved and/or refrigerated immediately upon sampling according to established protocols.

Whole sediment samples. For whole sediment samples, surficial sediments were collected in the field by removing several scrapes from the top four to five centimeters with clean (acid washed) stainless steel shovel or poly sample bottles. Sediment grab samples were then composited into either a clean pre-labeled stainless steel bowl or a poly opaque five gallon bucket (depending upon quantity required for subsequent testing and/or analysis). Sediment samples were then homogenized with a stainless steel spoon, aliquoted into amber borosilicate glass bottles with Teflon lined lids then placed into coolers and returned to the laboratory. Sediments collected in five gallon buckets were tightly capped and returned to the laboratory. Upon arrival, all sediment samples were stored at 5° C until testing. Prior to laboratory toxicity testing and/or chemical analyses, all sediment samples were again manually homogenized in the laboratory with stainless steel spoons for five to ten minutes.

Water samples. For *in situ* exposures, discrete unfiltered overlying water samples and chamber exposure samples (within chamber water samples) were collected for chemical analysis. Unfiltered Chamber water samples were extracted from each chamber, either via syringes fitted to ports incorporated into the chambers or from a series of water monitoring chambers of exact size and dimension installed side by side with exposure chambers. Water quality monitoring chambers were brushed off under the surface of the water and the contents transferred to a clean poly container so samples could be thoroughly composited and aliquoted into the appropriate pre-labeled sample containers. Pore water (interstitial water) samples were also collected from mini monitoring wells for analysis. All water samples were composited by treatment type and by site. Sample container type (*i.e.*, size, plastic, glass etc.) and preservative followed EPA approved sampling protocols and specific chemical analyses

requirements. All samples were transported back to the laboratory in 4° C coolers and refrigerated upon return.

Overlying site water samples were collected in clean, per-labeled, plastic or amber borosilicate glass bottles dependent upon analysis requirements as dictated by EPA sampling and testing protocols. Prior to sample collection, sample bottles were rinsed two to three times with sample water prior to sample collection. Water samples were then placed in coolers containing crushed or blue ice for transport. All water samples were and maintained at 4-5° C until analysis.

Shipment. Samples were delivered to either Dr. Thomas Teirnan at Wright State University, Dayton, Ohio, MSE/HKM Laboratory in Butte, Montana or Brookside Laboratory, New Knoxville, Ohio within 24 hrs to three days of collection (depending upon day of week that tests were ended or samples collected). For all sediment, water and biological samples, chain of custody forms and sample labeling followed protocols established by the contract laboratory whose services were rendered. Samples shipped out of the laboratory for analyses were packaged in hard plastic coolers insulated with newspaper and/or foam peanuts. Individual sample containers were wrapped in bubble wrap and incased in zip top bags to prevent cross contamination in the event of breakage or leakage. Sample bottle labels were covered with clear tape to keep labels intact in the event of water contact or condensation due to cold shipment. Blue ice packets were included in all coolers with samples requiring cold preservation. Coolers lids were taped closed prior to shipment. Chain of custody forms were also placed in the coolers in zip top bags. For in house chemical analyses (research samples), very specific labeling procedures and diligent sample logging was conducted, however, chain of custody forms were not required for research purposes.

Treatments, chemical analyses and *in situ* and laboratory test duration varied from year to year, test to test and site to site depending upon study goals established for each year of research.

Tissue samples. *L. variegatus* tissues collected for PCB and PAH analysis. *L. variegatus* were exposed at all sites in both water column and surficial water chambers. Following exposures, chambers were collected and processed in the field or laboratory according to previously discussed procedures. Any surviving *L. variegatus* were collected and placed into clean beakers of culture water. The four replicates for each treatment were pooled (*i.e.*, all worms for

the 4 replicates were placed into the same beaker of water). Following collection of all the worms, any debris was cleared out of the culture water and from the worms and the organisms were allowed to depurate (gut purging) for 6-36 hours. Six hours is the minimum recommended depuration time for *L. variegatus* bioaccumulation studies (Mount, 1999). After the depuration period, overlying water was decanted from the beakers and the tissues were blotted of any excess water using clean paper toweling. The tissue samples were then placed into pre-weighed/pre-labeled 40 mL amber vials and weighed for wet weight determination. Following wet weight analysis, tissues were extracted with dichloromethane and placed in the freezer until being relinquished to Dr. Thomas Tiernan, Wright State University for residue analysis.

Physicochemistry. Water quality parameters, at a minimum, were measured at test initiation then again at test termination at each field site for each of the following: temperature (°C), dissolved oxygen (mg/L) pH, hardness (mg/L CaCO₃), alkalinity (mg/L CaCO₃), conductivity (µmhos) and ammonia (total ammonia). All field and laboratory water quality monitoring equipment was calibrated prior to each use according to EPA and/or instrument specifications.

Appendix F

Chemical Analyses

AK5 041817

Water, sediment and tissue samples analyzed for PAHs and PCBs on a GC/MS-QP5050A (gas chromatography/mass spectrophotometry). Samples were analyzed via SIM (single ion monitoring) which allows a larger number of compounds to be analyzed simultaneously with high sensitivity PAH extraction and clean-up procedures followed EPA Method 8207C, semivolatile organic compounds by gas chromatography/mass spec., capillary column technique guidelines. PCB extraction and clean-up procedures followed EPA Draft Method 1668, measurement of toxic PCB isomers by isotope dilution high-resolution gas chromatography/high resolution mass spec (Oct. 1994).

AK5 041818

Appendix G

Qualitative Habitat Evaluation Index

AK5 041819

Appendix G

Qualitative Habitat Evaluation Index

AK5 041819

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (FRONT)

STREAM NAME <u>Little Sugar Creek</u>		LOCATION <u>upstr. Swigert Rd - Green County, OH</u>	
STATION # _____ RIVERMILE _____		STREAM CLASS _____	
LAT _____ LONG _____		RIVER BASIN <u>Little Miami</u>	
STORET # _____		AGENCY <u>WSU</u>	
INVESTIGATORS <u>G.A. BURTON</u>			
FORM COMPLETED BY _____		DATE <u>8-30-00</u> TIME <u>5:00</u> AM <input checked="" type="radio"/> PM <input type="radio"/>	REASON FOR SURVEY <u>USEPA Project</u>

WEATHER CONDITIONS	<table style="width: 100%;"> <tr> <td style="width: 33%;"> Now <input type="checkbox"/> storm (heavy rain) <input type="checkbox"/> rain (steady rain) <input type="checkbox"/> showers (intermittent) <input type="checkbox"/> %cloud cover _____ <input checked="" type="checkbox"/> clear/sunny </td> <td style="width: 33%;"> Past 24 hours <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> % <input checked="" type="checkbox"/> </td> <td style="width: 33%;"> Has there been a heavy rain in the last 7 days? <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No Air Temperature <u>30</u>°C <u>Aug 29, 2000</u> Other _____ </td> </tr> </table>	Now <input type="checkbox"/> storm (heavy rain) <input type="checkbox"/> rain (steady rain) <input type="checkbox"/> showers (intermittent) <input type="checkbox"/> %cloud cover _____ <input checked="" type="checkbox"/> clear/sunny	Past 24 hours <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> % <input checked="" type="checkbox"/>	Has there been a heavy rain in the last 7 days? <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No Air Temperature <u>30</u> °C <u>Aug 29, 2000</u> Other _____
Now <input type="checkbox"/> storm (heavy rain) <input type="checkbox"/> rain (steady rain) <input type="checkbox"/> showers (intermittent) <input type="checkbox"/> %cloud cover _____ <input checked="" type="checkbox"/> clear/sunny	Past 24 hours <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> % <input checked="" type="checkbox"/>	Has there been a heavy rain in the last 7 days? <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No Air Temperature <u>30</u> °C <u>Aug 29, 2000</u> Other _____		
SITE LOCATION/MAP	<p>Draw a map of the site and indicate the areas sampled (or attach a photograph)</p> <div style="text-align: center;"> </div> <p><u>Digital Pics #s 1-3 - upstream</u></p>			
STREAM CHARACTERIZATION	<table style="width: 100%;"> <tr> <td style="width: 50%;"> Stream Subsystem <input checked="" type="checkbox"/> Perennial <input type="checkbox"/> Intermittent <input type="checkbox"/> Tidal Stream Origin <input type="checkbox"/> Glacial <input type="checkbox"/> Spring-fed <input type="checkbox"/> Non-glacial montane <input checked="" type="checkbox"/> Mixture of origins <input type="checkbox"/> Swamp and bog <input type="checkbox"/> Other _____ </td> <td style="width: 50%;"> Stream Type <input type="checkbox"/> Coldwater <input checked="" type="checkbox"/> Warmwater Catchment Area _____ km² </td> </tr> </table> <p style="text-align: right;">AK5 041820</p>	Stream Subsystem <input checked="" type="checkbox"/> Perennial <input type="checkbox"/> Intermittent <input type="checkbox"/> Tidal Stream Origin <input type="checkbox"/> Glacial <input type="checkbox"/> Spring-fed <input type="checkbox"/> Non-glacial montane <input checked="" type="checkbox"/> Mixture of origins <input type="checkbox"/> Swamp and bog <input type="checkbox"/> Other _____	Stream Type <input type="checkbox"/> Coldwater <input checked="" type="checkbox"/> Warmwater Catchment Area _____ km ²	
Stream Subsystem <input checked="" type="checkbox"/> Perennial <input type="checkbox"/> Intermittent <input type="checkbox"/> Tidal Stream Origin <input type="checkbox"/> Glacial <input type="checkbox"/> Spring-fed <input type="checkbox"/> Non-glacial montane <input checked="" type="checkbox"/> Mixture of origins <input type="checkbox"/> Swamp and bog <input type="checkbox"/> Other _____	Stream Type <input type="checkbox"/> Coldwater <input checked="" type="checkbox"/> Warmwater Catchment Area _____ km ²			

North Br
 7-upstr. Dicks
 & downstr. stream
 0000 Dicks
 A-5-0-0

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (BACK)

WATERSHED FEATURES <i>Dominate</i>	Predominant Surrounding Landuse <input checked="" type="checkbox"/> Forest <input type="checkbox"/> Commercial <input checked="" type="checkbox"/> Field/Pasture <input type="checkbox"/> Industrial <input checked="" type="checkbox"/> Agricultural <input type="checkbox"/> Other _____ <input checked="" type="checkbox"/> Residential		Local Watershed NPS Pollution <input checked="" type="checkbox"/> No evidence <input type="checkbox"/> Some potential sources <input type="checkbox"/> Obvious sources
	Local Watershed Erosion <input type="checkbox"/> None <input checked="" type="checkbox"/> Moderate <input type="checkbox"/> Heavy		
RIPARIAN VEGETATION (18 meter buffer)	Indicate the dominant type and record the dominant species present <input type="checkbox"/> Trees <input type="checkbox"/> Shrubs <input type="checkbox"/> Grasses <input type="checkbox"/> Herbaceous dominant species present <u>Mixture-forest</u>		
INSTREAM FEATURES <i>(with sight)</i>	Estimated Reach Length <u>50</u> m Estimated Stream Width <u>3</u> m Sampling Reach Area _____ m ² Area in km ² (m ² x 1000) _____ km ² Estimated Stream Depth <u>0.1</u> m Surface Velocity <u>0.2</u> m/sec (at thalweg)	Canopy Cover <input checked="" type="checkbox"/> Partly open <input type="checkbox"/> Partly shaded <input type="checkbox"/> Shaded High Water Mark <u>2</u> m Proportion of Reach Represented by Stream Morphology Types <input checked="" type="checkbox"/> Riffle <u>10</u> % <input checked="" type="checkbox"/> Run <u>90</u> % <input checked="" type="checkbox"/> Pool <u>0</u> % Channelized <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No Dam Present <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	
LARGE WOODY DEBRIS	LWD <u>2</u> m ³ Density of LWD <u>2%</u> bank m ³ /km ² (LWD/ reach area)		
AQUATIC VEGETATION	Indicate the dominant type and record the dominant species present <input type="checkbox"/> Rooted emergent <input type="checkbox"/> Rooted submergent <input type="checkbox"/> Rooted floating <input type="checkbox"/> Free floating <input type="checkbox"/> Floating Algae <input type="checkbox"/> Attached Algae dominant species present _____ Portion of the reach with aquatic vegetation <u>0</u> %		
WATER QUALITY	Temperature _____ °C Specific Conductance _____ Dissolved Oxygen _____ pH _____ Turbidity _____ WQ Instrument Used _____	Water Odors <input checked="" type="checkbox"/> Normal/None <input type="checkbox"/> Sewage <input type="checkbox"/> Petroleum <input type="checkbox"/> Chemical <input type="checkbox"/> Fishy <input type="checkbox"/> Other _____ Water Surface Oils <input type="checkbox"/> Slick <input type="checkbox"/> Sheen <input type="checkbox"/> Globs <input type="checkbox"/> Flecks <input checked="" type="checkbox"/> None <input type="checkbox"/> Other _____ Turbidity (if not measured) <input checked="" type="checkbox"/> Clear <input type="checkbox"/> Slightly turbid <input type="checkbox"/> Turbid <input type="checkbox"/> Opaque <input type="checkbox"/> Stained <input type="checkbox"/> Other _____	
SEDIMENT/SUBSTRATE	Odors <input checked="" type="checkbox"/> Normal <input type="checkbox"/> Sewage <input type="checkbox"/> Petroleum <input type="checkbox"/> Chemical <input type="checkbox"/> Anaerobic <input checked="" type="checkbox"/> None <input type="checkbox"/> Other _____ Oils <input checked="" type="checkbox"/> Absent <input type="checkbox"/> Slight <input type="checkbox"/> Moderate <input type="checkbox"/> Profuse Deposits <input type="checkbox"/> Sludge <input type="checkbox"/> Sawdust <input type="checkbox"/> Paper fiber <input checked="" type="checkbox"/> Sand <input type="checkbox"/> Relict shells <input type="checkbox"/> Other <u>Gavel</u> Looking at stones which are not deeply embedded, are the undersides black in color? <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No		

INORGANIC SUBSTRATE COMPONENTS (should add up to 100%)			ORGANIC SUBSTRATE COMPONENTS (does not necessarily add up to 100%)		
Substrate Type	Diameter	% Composition in Sampling Reach	Substrate Type	Characteristic	% Composition in Sampling Area
Bedrock		0	Detritus	sticks, wood, coarse plant materials (CPOM)	0
Boulder	> 256 mm (10")	5 (rip rap)			
Cobble	64-256 mm (2.5"-10")	5			
Gravel	2-64 mm (0.1"-2.5")	70	Muck-Mud	black, very fine organic (FPOM)	0
Sand	0.06-2mm (gritty)	20	Marl	grey, shell fragments	0
Silt	0.004-0.06 mm	0			
Clay	< 0.004 mm (slick)	0			

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (FRONT)

STREAM NAME		LOCATION	
STATION # _____ RIVERMILE _____		STREAM CLASS	
LAT _____ LONG _____		RIVER BASIN	
STORET #		AGENCY	
INVESTIGATORS			
FORM COMPLETED BY		DATE _____ TIME _____ AM PM	REASON FOR SURVEY

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of new fall, but not yet prepared for colonization (may rate at high end of scale).	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than <20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 70-80% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (BACK)

Habitat Parameter	Condition Category																				
	Optimal					Suboptimal					Marginal					Poor					
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.					Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.					Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.					Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.					
SCORE	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)					The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.					The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.					Channel straight; waterway has been channelized for a long distance.					
SCORE	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.					Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.					Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.					Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.					
SCORE ____ (LB)	Left Bank 10 9					8 7 6					5 4 3					2 1 0					
SCORE ____ (RB)	Right Bank 10 9					8 7 6					5 4 3					2 1 0					
9. Vegetative Protection (score each bank) Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.					70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.					50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.					Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.					
SCORE ____ (LB)	Left Bank 10 9					8 7 6					5 4 3					2 1 0					
SCORE ____ (RB)	Right Bank 10 9					8 7 6					5 4 3					2 1 0					
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.					Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.					Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.					Width of riparian zone <6 meters; little or no riparian vegetation due to human activities.					
SCORE ____ (LB)	Left Bank 10 9					8 7 6					5 4 3					2 1 0					
SCORE ____ (RB)	Right Bank 10 9					8 7 6					5 4 3					2 1 0					

Total Score 115

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (FRONT)

STREAM NAME <u>Red Hunter Cr.</u>		LOCATION <u>Red Hunter Rd</u>	
STATION # _____ RIVERMILE _____		STREAM CLASS _____	
LAT _____ LONG _____		RIVER BASIN <u>Gr. Miami na Dicks Creek</u>	
STORET # _____		AGENCY <u>WSU</u>	
INVESTIGATORS _____			
FORM COMPLETED BY _____		DATE <u>8-29</u> TIME <u>4:15</u> AM <input checked="" type="radio"/> PM <input type="radio"/>	REASON FOR SURVEY <u>USEPA Project</u>

WEATHER CONDITIONS	<table style="width: 100%;"> <tr> <td style="width: 50%;"> Now <input type="checkbox"/> storm (heavy rain) <input type="checkbox"/> rain (steady rain) <input type="checkbox"/> showers (intermittent) <input type="checkbox"/> %cloud cover _____ <input checked="" type="checkbox"/> clear/sunny </td> <td style="width: 50%;"> Past 24 hours <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/> 50% <input type="checkbox"/> </td> </tr> <tr> <td colspan="2"> Has there been a heavy rain in the last 7 days? <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No <u>Aug 27</u> Air Temperature <u>30</u>°C Other _____ </td> </tr> </table>	Now <input type="checkbox"/> storm (heavy rain) <input type="checkbox"/> rain (steady rain) <input type="checkbox"/> showers (intermittent) <input type="checkbox"/> %cloud cover _____ <input checked="" type="checkbox"/> clear/sunny	Past 24 hours <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/> 50% <input type="checkbox"/>	Has there been a heavy rain in the last 7 days? <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No <u>Aug 27</u> Air Temperature <u>30</u> °C Other _____	
Now <input type="checkbox"/> storm (heavy rain) <input type="checkbox"/> rain (steady rain) <input type="checkbox"/> showers (intermittent) <input type="checkbox"/> %cloud cover _____ <input checked="" type="checkbox"/> clear/sunny	Past 24 hours <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/> 50% <input type="checkbox"/>				
Has there been a heavy rain in the last 7 days? <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No <u>Aug 27</u> Air Temperature <u>30</u> °C Other _____					
SITE LOCATION/MAP	<p>Draw a map of the site and indicate the areas sampled (or attach a photograph)</p> <div style="text-align: center;"> </div> <p>Digital Pics # 11 & 12 - downstr. only</p>				
STREAM CHARACTERIZATION	<table style="width: 100%;"> <tr> <td style="width: 50%;"> Stream Subsystem <input type="checkbox"/> Perennial <input checked="" type="checkbox"/> Intermittent <input type="checkbox"/> Tidal Stream Origin <input type="checkbox"/> Glacial <input type="checkbox"/> Spring-fed <input type="checkbox"/> Non-glacial montane <input checked="" type="checkbox"/> Mixture of origins <input type="checkbox"/> Swamp and bog <input type="checkbox"/> Other _____ </td> <td style="width: 50%;"> Stream Type <input type="checkbox"/> Coldwater <input checked="" type="checkbox"/> Warmwater Catchment Area _____ km² </td> </tr> </table>	Stream Subsystem <input type="checkbox"/> Perennial <input checked="" type="checkbox"/> Intermittent <input type="checkbox"/> Tidal Stream Origin <input type="checkbox"/> Glacial <input type="checkbox"/> Spring-fed <input type="checkbox"/> Non-glacial montane <input checked="" type="checkbox"/> Mixture of origins <input type="checkbox"/> Swamp and bog <input type="checkbox"/> Other _____	Stream Type <input type="checkbox"/> Coldwater <input checked="" type="checkbox"/> Warmwater Catchment Area _____ km ²		
Stream Subsystem <input type="checkbox"/> Perennial <input checked="" type="checkbox"/> Intermittent <input type="checkbox"/> Tidal Stream Origin <input type="checkbox"/> Glacial <input type="checkbox"/> Spring-fed <input type="checkbox"/> Non-glacial montane <input checked="" type="checkbox"/> Mixture of origins <input type="checkbox"/> Swamp and bog <input type="checkbox"/> Other _____	Stream Type <input type="checkbox"/> Coldwater <input checked="" type="checkbox"/> Warmwater Catchment Area _____ km ²				

Northern
 1 - upstr Dicks
 X downstr stream
 A-5

Ed Hunter

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (BACK)

WATERSHED FEATURES	Predominant Surrounding Landuse <input checked="" type="checkbox"/> Forest <input type="checkbox"/> Commercial <input type="checkbox"/> Field/Pasture <input checked="" type="checkbox"/> Industrial <input checked="" type="checkbox"/> Agricultural <input type="checkbox"/> Other _____ <input type="checkbox"/> Residential		Local Watershed NPS Pollution <input type="checkbox"/> No evidence <input checked="" type="checkbox"/> Some potential sources <i>ag/iz</i> <input type="checkbox"/> Obvious sources Local Watershed Erosion <input type="checkbox"/> None <input checked="" type="checkbox"/> Moderate <i>Low</i> <input type="checkbox"/> Heavy
RIPARIAN VEGETATION (18 meter buffer)	Indicate the dominant type and record the dominant species present <input type="checkbox"/> Trees <input type="checkbox"/> Shrubs <input type="checkbox"/> Grasses <input type="checkbox"/> Herbaceous dominant species present <i>All - mixture</i>		
INSTREAM FEATURES <i>win sight</i>	Estimated Reach Length <i>50</i> m Estimated Stream Width <i>2-6</i> m Sampling Reach Area _____ m ² Area in km² (m²x1000) _____ km ² Estimated Stream Depth <i>0.5</i> m Surface Velocity <i>0.1</i> m/sec (at thalweg)	Canopy Cover <input checked="" type="checkbox"/> Partly open <input type="checkbox"/> Partly shaded <input type="checkbox"/> Shaded High Water Mark <i>1.5</i> m Proportion of Reach Represented by Stream Morphology Types <input type="checkbox"/> Riffle <i>10</i> % <input type="checkbox"/> Run <i>60</i> % <input type="checkbox"/> Pool <i>30</i> % Channelized <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No Dam Present <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	
LARGE WOODY DEBRIS	LWD _____ m ² Density of LWD _____ m ² /km ² (LWD/ reach area)		
AQUATIC VEGETATION	Indicate the dominant type and record the dominant species present <input checked="" type="checkbox"/> Rooted emergent <input type="checkbox"/> Rooted submergent <input type="checkbox"/> Rooted floating <input type="checkbox"/> Free floating <input type="checkbox"/> Floating Algae <input type="checkbox"/> Attached Algae dominant species present _____ Portion of the reach with aquatic vegetation <i>10</i> %		
WATER QUALITY	Temperature _____ °C Specific Conductance _____ Dissolved Oxygen _____ pH _____ Turbidity _____ WQ Instrument Used _____	Water Odors <input checked="" type="checkbox"/> Normal/None <input type="checkbox"/> Sewage <input type="checkbox"/> Petroleum <input type="checkbox"/> Chemical <input type="checkbox"/> Fishy <input type="checkbox"/> Other _____ Water Surface Oils <input type="checkbox"/> Slick <input type="checkbox"/> Sheen <input type="checkbox"/> Globbs <input type="checkbox"/> Flecks <input checked="" type="checkbox"/> None <input type="checkbox"/> Other _____ Turbidity (if not measured) <input checked="" type="checkbox"/> Clear <input type="checkbox"/> Slightly turbid <input type="checkbox"/> Turbid <input type="checkbox"/> Opaque <input type="checkbox"/> Stained <input type="checkbox"/> Other _____	
SEDIMENT/ SUBSTRATE	Odors <input type="checkbox"/> Normal <input type="checkbox"/> Sewage <input type="checkbox"/> Petroleum <input type="checkbox"/> Chemical <input type="checkbox"/> Anaerobic <input checked="" type="checkbox"/> None <input type="checkbox"/> Other _____ Oils <input checked="" type="checkbox"/> Absent <input type="checkbox"/> Slight <input type="checkbox"/> Moderate <input type="checkbox"/> Profuse Deposits <input type="checkbox"/> Sludge <input type="checkbox"/> Sawdust <input type="checkbox"/> Paper fiber <input type="checkbox"/> Sand <input type="checkbox"/> Relict shells <input type="checkbox"/> Other _____ Looking at stones which are not deeply embedded, are the undersides black in color? <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No		

INORGANIC SUBSTRATE COMPONENTS (should add up to 100%)			ORGANIC SUBSTRATE COMPONENTS (does not necessarily add up to 100%)		
Substrate Type	Diameter	% Composition in Sampling Reach	Substrate Type	Characteristic	% Composition in Sampling Area
Bedrock		0	Detritus	sticks, wood, coarse plant materials (CPOM)	0
Boulder	> 256 mm (10")	2			
Cobble	64-256 mm (2.5"-10")	10	Muck-Mud	black, very fine organic (FPOM)	0
Gravel	2-64 mm (0.1"-2.5")	50			
Sand	0.06-2mm (gritty)	20	Marl	grey, shell fragments	0
Silt	0.004-0.06 mm	18			
Clay	< 0.004 mm (slick)	1			

Ted Hunter

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (BACK)

Habitat Parameter	Condition Category																				
	Optimal					Suboptimal					Marginal					Poor					
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.					Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.					Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.					Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.					
SCORE	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)					The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.					The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.					Channel straight; waterway has been channelized for a long distance.					
SCORE	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.					Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.					Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.					Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.					
SCORE ____ (LB)	Left Bank 10 9					8 7 6					5 4 3					2 1 0					
SCORE ____ (RB)	Right Bank 10 9					8 7 6					5 4 3					2 1 0					
9. Vegetative Protection (score each bank)	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.					70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.					50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.					Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.					
SCORE ____ (LB)	Left Bank 10 9					8 7 6					5 4 3					2 1 0					
SCORE ____ (RB)	Right Bank 10 9					8 7 6					5 4 3					2 1 0					
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.					Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.					Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.					Width of riparian zone <6 meters; little or no riparian vegetation due to human activities.					
SCORE ____ (LB)	Left Bank 10 9					8 7 6					5 4 3					2 1 0					
SCORE ____ (RB)	Right Bank 10 9					8 7 6					5 4 3					2 1 0					

Total Score 102

AK5 041827

Ted Hunter

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (FRONT)

STREAM NAME		LOCATION	
STATION # _____ RIVERMILE _____		STREAM CLASS	
LAT _____ LONG _____		RIVER BASIN	
STORET # _____		AGENCY	
INVESTIGATORS			
FORM COMPLETED BY		DATE _____ TIME _____ AM PM	REASON FOR SURVEY

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than <20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (FRONT)

STREAM NAME <u>Dicks Cr.</u>		LOCATION <u>USGS Gauge</u>	
STATION # _____ RIVERMILE _____		STREAM CLASS _____	
LAT _____ LONG _____		RIVER BASIN <u>Gr. Miami</u>	
STORET # _____		AGENCY <u>WSU</u>	
INVESTIGATORS <u>G. A. Burton</u>			
FORM COMPLETED BY <u>u</u>		DATE <u>8-29-00</u> TIME <u>4:00</u> AM <input checked="" type="radio"/> PM	REASON FOR SURVEY _____

WEATHER CONDITIONS	<table style="width: 100%;"> <tr> <td style="width: 50%;"> Now <input type="checkbox"/> storm (heavy rain) <input type="checkbox"/> rain (steady rain) <input type="checkbox"/> showers (intermittent) <input type="checkbox"/> %cloud cover _____ <input checked="" type="checkbox"/> clear/sunny </td> <td style="width: 50%;"> Past 24 hours <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/> 50% <input type="checkbox"/> </td> </tr> <tr> <td colspan="2"> Has there been a heavy rain in the last 7 days? <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No <u>Aug 27</u> Air Temperature <u>32</u> °C Other _____ </td> </tr> </table>	Now <input type="checkbox"/> storm (heavy rain) <input type="checkbox"/> rain (steady rain) <input type="checkbox"/> showers (intermittent) <input type="checkbox"/> %cloud cover _____ <input checked="" type="checkbox"/> clear/sunny	Past 24 hours <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/> 50% <input type="checkbox"/>	Has there been a heavy rain in the last 7 days? <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No <u>Aug 27</u> Air Temperature <u>32</u> °C Other _____	
Now <input type="checkbox"/> storm (heavy rain) <input type="checkbox"/> rain (steady rain) <input type="checkbox"/> showers (intermittent) <input type="checkbox"/> %cloud cover _____ <input checked="" type="checkbox"/> clear/sunny	Past 24 hours <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/> 50% <input type="checkbox"/>				
Has there been a heavy rain in the last 7 days? <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No <u>Aug 27</u> Air Temperature <u>32</u> °C Other _____					
SITE LOCATION/MAP	<p>Draw a map of the site and indicate the areas sampled (or attach a photograph)</p> <p style="text-align: right;">Digital pics # 14 & 13</p>				
STREAM CHARACTERIZATION	<table style="width: 100%;"> <tr> <td style="width: 50%;"> Stream Subsystem <input checked="" type="checkbox"/> Perennial <input type="checkbox"/> Intermittent <input type="checkbox"/> Tidal Stream Origin <input type="checkbox"/> Glacial <input type="checkbox"/> Spring-fed <input type="checkbox"/> Non-glacial montane <input checked="" type="checkbox"/> Mixture of origins <input type="checkbox"/> Swamp and bog <input type="checkbox"/> Other _____ </td> <td style="width: 50%;"> Stream Type <input type="checkbox"/> Coldwater <input checked="" type="checkbox"/> Warmwater Catchment Area _____ km² </td> </tr> </table>	Stream Subsystem <input checked="" type="checkbox"/> Perennial <input type="checkbox"/> Intermittent <input type="checkbox"/> Tidal Stream Origin <input type="checkbox"/> Glacial <input type="checkbox"/> Spring-fed <input type="checkbox"/> Non-glacial montane <input checked="" type="checkbox"/> Mixture of origins <input type="checkbox"/> Swamp and bog <input type="checkbox"/> Other _____	Stream Type <input type="checkbox"/> Coldwater <input checked="" type="checkbox"/> Warmwater Catchment Area _____ km ²		
Stream Subsystem <input checked="" type="checkbox"/> Perennial <input type="checkbox"/> Intermittent <input type="checkbox"/> Tidal Stream Origin <input type="checkbox"/> Glacial <input type="checkbox"/> Spring-fed <input type="checkbox"/> Non-glacial montane <input checked="" type="checkbox"/> Mixture of origins <input type="checkbox"/> Swamp and bog <input type="checkbox"/> Other _____	Stream Type <input type="checkbox"/> Coldwater <input checked="" type="checkbox"/> Warmwater Catchment Area _____ km ²				

North Br
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& down stream
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PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (BACK)

WATERSHED FEATURES	Predominant Surrounding Landuse <input checked="" type="checkbox"/> Forest <input type="checkbox"/> Commercial <input type="checkbox"/> Field/Pasture <input type="checkbox"/> Industrial <input type="checkbox"/> Agricultural <input type="checkbox"/> Other _____ <input type="checkbox"/> Residential		Local Watershed NPS Pollution <input type="checkbox"/> No evidence <input checked="" type="checkbox"/> Some potential sources <i>local agric</i> <input type="checkbox"/> Obvious sources Local Watershed Erosion <input type="checkbox"/> None <input checked="" type="checkbox"/> Moderate <input type="checkbox"/> Heavy
RIPARIAN VEGETATION (18 meter buffer)	Indicate the dominant type and record the dominant species present <input checked="" type="checkbox"/> Trees <input type="checkbox"/> Shrubs <input type="checkbox"/> Grasses <input type="checkbox"/> Herbaceous dominant species present _____		
INSTREAM FEATURES <i>with sight</i>	Estimated Reach Length <u>75</u> m Estimated Stream Width <u>20</u> m Sampling Reach Area _____ m ² Area in km² (m²x1000) _____ km ² Estimated Stream Depth <u>1-2</u> m Surface Velocity (at thalweg) <u>0.2</u> m/sec Canopy Cover <input checked="" type="checkbox"/> Partly open <input type="checkbox"/> Partly shaded <input type="checkbox"/> Shaded High Water Mark <u>3</u> m Proportion of Reach Represented by Stream Morphology Types <input type="checkbox"/> Riffle <u>10</u> % <input type="checkbox"/> Run <u>25</u> % <input type="checkbox"/> Pool <u>65</u> % Channelized <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No Dam Present <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No		
LARGE WOODY DEBRIS	LWD _____ m ² Density of LWD <u>50 bank</u> m ² /km ² (LWD/ reach area)		
AQUATIC VEGETATION	Indicate the dominant type and record the dominant species present <input type="checkbox"/> Rooted emergent <input type="checkbox"/> Rooted submergent <input type="checkbox"/> Rooted floating <input type="checkbox"/> Free floating <input checked="" type="checkbox"/> Floating Algae <input type="checkbox"/> Attached Algae dominant species present <u>Blue green clumps</u> Portion of the reach with aquatic vegetation <u>80</u> %		
WATER QUALITY	Temperature _____ °C Specific Conductance _____ Dissolved Oxygen _____ pH _____ Turbidity _____ WQ Instrument Used _____ Water Odors <input checked="" type="checkbox"/> Normal/None <input type="checkbox"/> Sewage <input type="checkbox"/> Petroleum <input type="checkbox"/> Chemical <input type="checkbox"/> Fishy <input type="checkbox"/> Other _____ Water Surface Oils <input type="checkbox"/> Slick <input type="checkbox"/> Sheen <input type="checkbox"/> Globbs <input type="checkbox"/> Flecks <input checked="" type="checkbox"/> None <input type="checkbox"/> Other _____ Turbidity (if not measured) <input type="checkbox"/> Clear <input checked="" type="checkbox"/> Slightly turbid <input type="checkbox"/> Turbid <input type="checkbox"/> Opaque <input type="checkbox"/> Stained <input type="checkbox"/> Other _____		
SEDIMENT/ SUBSTRATE	Odors <input checked="" type="checkbox"/> Normal <input type="checkbox"/> Sewage <input type="checkbox"/> Petroleum <input type="checkbox"/> Chemical <input type="checkbox"/> Anaerobic <input type="checkbox"/> None <input type="checkbox"/> Other _____ Oils <input checked="" type="checkbox"/> Absent <input type="checkbox"/> Slight <input type="checkbox"/> Moderate <input type="checkbox"/> Profuse Deposits <input type="checkbox"/> Sludge <input type="checkbox"/> Sawdust <input type="checkbox"/> Paper fiber <input type="checkbox"/> Sand <input type="checkbox"/> Relict shells <input type="checkbox"/> Other _____ Looking at stones which are not deeply embedded, are the undersides black in color? <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No		

INORGANIC SUBSTRATE COMPONENTS (should add up to 100%)			ORGANIC SUBSTRATE COMPONENTS (does not necessarily add up to 100%)		
Substrate Type	Diameter	% Composition in Sampling Reach	Substrate Type	Characteristic	% Composition in Sampling Area
Bedrock		0	Detritus	sticks, wood, coarse plant materials (CPOM)	0
Boulder	> 256 mm (10")	0	Muck-Mud	black, very fine organic (FPOM)	0
Cobble	64-256 mm (2.5"-10")	5	Marl	grey, shell fragments	0
Gravel	2-64 mm (0.1"-2.5")	70			
Sand	0.06-2mm (gritty)	5			
Silt	0.004-0.06 mm	25			
Clay	< 0.004 mm (slick)	↓			

Silt/clay covering all surfaces

USGS

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (FRONT)

STREAM NAME _____		LOCATION _____	
STATION # _____ RIVERMILE _____		STREAM CLASS _____	
LAT _____ LONG _____		RIVER BASIN _____	
STORET # _____		AGENCY _____	
INVESTIGATORS _____			
FORM COMPLETED BY _____		DATE _____ AM _____ PM _____	REASON FOR SURVEY _____

	Habitat Parameter	Condition Category			
		Optimal	Suboptimal	Marginal	Poor
Parameters to be evaluated in sampling reach	1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
	SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.
	SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
	SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	4. Sediment Deposition	Little or no enlargement of islands or point bars and less than <20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
	SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
	SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

39

AK5 041830

W60

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (BACK)

Habitat Parameter	Condition Category																				
	Optimal					Suboptimal					Marginal					Poor					
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.					Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.					Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.					Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.					
SCORE	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)					The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.					The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.					Channel straight; waterway has been channelized for a long distance.					
SCORE	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.					Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.					Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.					Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.					
SCORE ____ (LB)	Left Bank 10 9					8 7 6					5 4 3					2 1 0					
SCORE ____ (RB)	Right Bank 10 9					8 7 6					5 4 3					2 1 0					
9. Vegetative Protection (score each bank) Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.					70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.					50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.					Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.					
SCORE ____ (LB)	Left Bank 10 9					8 7 6					5 4 3					2 1 0					
SCORE ____ (RB)	Right Bank 10 9					8 7 6					5 4 3					2 1 0					
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.					Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.					Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.					Width of riparian zone <6 meters; little or no riparian vegetation due to human activities.					
SCORE ____ (LB)	Left Bank 10 9					8 7 6					5 4 3					2 1 0					
SCORE ____ (RB)	Right Bank 10 9					8 7 6					5 4 3					2 1 0					

Parameters to be evaluated broader than sampling reach

Total Score 81

STREAM NAME <u>Dicks Creek</u>	LOCATION <u>Amanda</u>	
STATION # _____ RIVERMILE _____	STREAM CLASS _____	
LAT _____ LONG _____	RIVER BASIN <u>Gr. Miami</u>	
STORET # _____	AGENCY <u>WSU</u>	
INVESTIGATORS <u>G. A. Burton</u>		
FORM COMPLETED BY <u>u</u>	DATE <u>8-29</u> TIME <u>330</u> AM <input checked="" type="radio"/> PM	REASON FOR SURVEY <u>USEPA Project</u>

Rapid Bioassessment Protocols For Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish, Second Edition - Form 1

AK5 041832

North Br

able Rivers: Periphyton, Benthic

7-watr Dick
+ densr str. Dick

A-5

Amanda

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (BACK)

WATERSHED FEATURES	Predominant Surrounding Landuse <input checked="" type="checkbox"/> Forest <input type="checkbox"/> Commercial <input checked="" type="checkbox"/> Field/Pasture <input type="checkbox"/> Industrial <input type="checkbox"/> Agricultural <input type="checkbox"/> Other _____ <input type="checkbox"/> Residential		Local Watershed NPS Pollution - water <input type="checkbox"/> No evidence <input type="checkbox"/> Some potential sources <input type="checkbox"/> Obvious sources Local Watershed Erosion <input type="checkbox"/> None <input checked="" type="checkbox"/> Moderate <input type="checkbox"/> Heavy
RIPARIAN VEGETATION (18 meter buffer)	Indicate the dominant type and record the dominant species present <input checked="" type="checkbox"/> Trees <input checked="" type="checkbox"/> Shrubs <input type="checkbox"/> Grasses <input type="checkbox"/> Herbaceous dominant species present <u>Forest mixture</u>		
INSTREAM FEATURES (w/in sight)	Estimated Reach Length <u>150</u> m Estimated Stream Width <u>30</u> m Sampling Reach Area _____ m ² Area in km² (m²x1000) _____ km ² Estimated Stream Depth <u>0.1-1</u> m Surface Velocity (at thalweg) <u>0.2</u> m/sec		Canopy Cover <input checked="" type="checkbox"/> Partly open <input type="checkbox"/> Partly shaded <input type="checkbox"/> Shaded High Water Mark <u>3</u> m Proportion of Reach Represented by Stream Morphology Types <input type="checkbox"/> Riffle <u>30</u> % <input type="checkbox"/> Run <u>40</u> % <input type="checkbox"/> Pool <u>30</u> % Channelized <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No Dam Present <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No
LARGE WOODY DEBRIS	LWD _____ m ² Density of LWD <u>20% bank</u> m ² /km ² (LWD/ reach area)		
AQUATIC VEGETATION	Indicate the dominant type and record the dominant species present <input type="checkbox"/> Rooted emergent <input type="checkbox"/> Rooted submergent <input type="checkbox"/> Rooted floating <input type="checkbox"/> Free floating <input type="checkbox"/> Floating Algae <input type="checkbox"/> Attached Algae dominant species present _____ Portion of the reach with aquatic vegetation <u>0</u> %		
WATER QUALITY	Temperature _____ °C Specific Conductance _____ Dissolved Oxygen _____ pH _____ Turbidity _____ WQ Instrument Used _____		Water Odors <input checked="" type="checkbox"/> Normal/None <input type="checkbox"/> Sewage <input type="checkbox"/> Petroleum <input type="checkbox"/> Chemical <input type="checkbox"/> Fishy <input type="checkbox"/> Other _____ Water Surface Oils <input type="checkbox"/> Slick <input type="checkbox"/> Sheen <input type="checkbox"/> Globbs <input type="checkbox"/> Flecks <input checked="" type="checkbox"/> None <input type="checkbox"/> Other _____ Turbidity (if not measured) <input type="checkbox"/> Clear <input checked="" type="checkbox"/> Slightly turbid <input type="checkbox"/> Turbid <input type="checkbox"/> Opaque <input type="checkbox"/> Stained <input type="checkbox"/> Other _____
SEDIMENT/ SUBSTRATE	Odors <input type="checkbox"/> Normal <input type="checkbox"/> Sewage <input type="checkbox"/> Petroleum <input type="checkbox"/> Chemical <input type="checkbox"/> Anaerobic <input checked="" type="checkbox"/> None <input type="checkbox"/> Other _____ Oils <input checked="" type="checkbox"/> Absent <input type="checkbox"/> Slight <input type="checkbox"/> Moderate <input type="checkbox"/> Profuse		Deposits <input type="checkbox"/> Sludge <input type="checkbox"/> Sawdust <input type="checkbox"/> Paper fiber <input type="checkbox"/> Sand <input type="checkbox"/> Relict shells <input type="checkbox"/> Other _____ Looking at stones which are not deeply embedded, are the undersides black in color? <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No

INORGANIC SUBSTRATE COMPONENTS (should add up to 100%)			ORGANIC SUBSTRATE COMPONENTS (does not necessarily add up to 100%)		
Substrate Type	Diameter	% Composition in Sampling Reach	Substrate Type	Characteristic	% Composition in Sampling Area
Bedrock		0	Detritus	sticks, wood, coarse plant materials (CPOM)	0
Boulder	> 256 mm (10")	0			
Cobble	64-256 mm (2.5"-10")	5	Muck-Mud	black, very fine organic (FPOM)	0
Gravel	2-64 mm (0.1"-2.5")	75			
Sand	0.06-2mm (gritty)	5	Marl	grey, shell fragments	0
Silt	0.004-0.06 mm	20			
Clay	< 0.004 mm (slick)	↓			

(Clay/Silt covering all surfaces)

AK5 041833

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (FRONT)

STREAM NAME _____		LOCATION _____	
STATION # _____ RIVERMILE _____		STREAM CLASS _____	
LAT _____ LONG _____		RIVER BASIN _____	
STORET # _____		AGENCY _____	
INVESTIGATORS _____			
FORM COMPLETED BY _____		DATE _____ TIME _____ AM PM	REASON FOR SURVEY _____

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category																				
	Optimal					Suboptimal					Marginal					Poor					
1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are <u>not</u> new fall and <u>not</u> transient).																				
SCORE	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.																				
SCORE	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.																				
SCORE	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than <20% of the bottom affected by sediment deposition.																				
SCORE	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.																				
SCORE	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Amanda

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (BACK)

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE __ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE __ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank) Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE __ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE __ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters; little or no riparian vegetation due to human activities.
SCORE __ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE __ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Total Score 100SE
42

AK5 041835

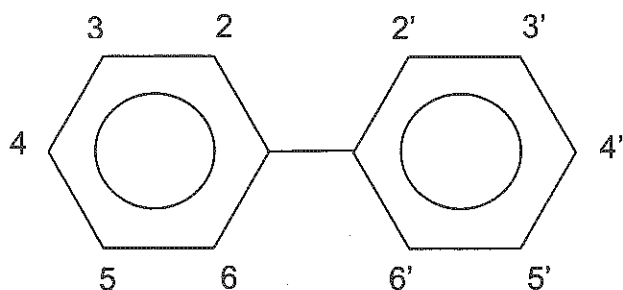
Appendix H

Polychlorinated Biphenyls

AK5 041836

The contaminants of concern identified for Dicks Creek are polychlorinated biphenyls, or PCBs. PCBs are a group of synthetic organic chemical consisting of 209 individual structurally different compounds, or congeners. Structurally, PCBs are two benzene rings bonded together by a single carbon-carbon bond substituted with varying degrees of chlorination. PCBs can be further subdivided into homologs which are groups with the same degree of chlorination, and isomers, which are the 209 individual compounds each with unique chlorine substitution patterns (Erickson). PCBs were marketed with respect to chlorination (by weight) since the percentage of the chlorine on a molecule or group of molecules drive the physical properties. Aroclor 1254, for example, indicates that the molecule contains 12 carbon atoms (the first two digits) and

Polychlorinated Biphenyl (PCB) $C_{12}H_{(10-n)}Cl_n$ (CAS # 1336363)



approximately 54% chlorine, weight, and two digits). Each Aroclor has a different quantity of homologs. The higher the chlorine percent weight, the greater the quantity of the higher chlorinated homolog groups.

PCBs with low chlorine substitution tend to be light, colorless oily fluids. Molecules of higher chlorine substitution tend to have characteristics of heavy, viscous, honey colored oils. They have no smell or taste. PCBs are either oily liquids or solids; however, commercial products generally are liquid due to a decreased melting point resultant of mixing. In general, melting point and lipophobicity increase with increasing degree of chlorination, while on the contrary, vapor pressure and water solubility decrease. Therefore, all PCB tend to be very water insoluble and lipophilic. Water solubilities for Aroclors are in the 0.4 to 0.2 mg/l range, rendering low mobility in ground water and surface water. When compared to other chemicals, PCBs have very high K_{OW} values. Log K_{OW} for monochlorobiphenyls are in the 4.5 range to > 8 for the

AK5 041837

higher chlorinated PCBs. Consequently, PCBs tend to adsorb to nonpolar surfaces and accumulate in lipophilic matrices in the aquatic and terrestrial food chain. PCBs also tend to strongly adhere to non-polar surfaces due to high K_{oc} (partition coefficients) values. PCBs are liquid at room temperature (density: 1.1821.566 kg/L), have low water solubility, readily soluble in organic solvents, have a high flash point (170-380°C, h), are non-explosive, have low electric conductivity, have very high thermal conductivity and have extremely high thermal and chemical resistance (very high stability).

PCBs were first manufactured in 1929 by the Monsanto Company and marketed under the name Aroclor. Between 1929 and 1977 most PCBs were sold for use as dielectric fluids (insulating liquids) because they are chemically and thermally stable and are good insulators. The manufacture of PCBs in the United States ceased in October 1977 due to evidence that PCBs build up in the environment and have harmful effects. Although PCBs are no longer commercially manufactured in the U.S., some electric transformers and capacitors utilizing PCBs as insulating liquids are still in use. Import and export of the compounds to/from the U.S. has been prohibited since 1979. There are no known natural sources of PCBs in the environment.

PCBs are problematic in the ecosystem as they are very persistent and are easily absorbed by most animals. PCBs in the aquatic environment are generally bound to particulates in the water and accumulate in sediments. Benthic organisms living in the sediment and ingesting sediment particles may accumulate high body burdens and thus transfer the compounds up the food web (Kukkonen, Landrum 1995). Scientific Studies have demonstrated that PCBs can bioaccumulate in the fatty tissue of fish, birds, and mammals, entering the body through the lungs, skin, or gastrointestinal tract (van Wezel et al. 1995, Bremle et al., 1998, Ankley et al., 1992 and Moore et al., 1999). Currently, no information is available on the acute effects of PCBs in humans, however animal studies have reported effects to the liver, kidney and central nervous system from oral exposures. PCBs are suspected human carcinogens and have been shown to be teratogenic (induce mutations in the offspring of affected individuals) in birds and mice. Two human studies investigating the consumption of PCB contaminated fish suggested that exposure may cause developmental effects in humans (ASTDR, USEPA, 1991c). The EPA has not established a Reference Concentration or a Reference Dose for PCB mixtures.

AK5 041838